THE EAST AFRICAN AGRICULTURAL JOURNAL

of

KENYA
TANGANYIKA
UGANDA AND
ZANZIBAR

Vol: XXIV—No. 4

APRIL
1959

World List abbreviation: *E. Afr. agric. J.*

IN THIS ISSUE:

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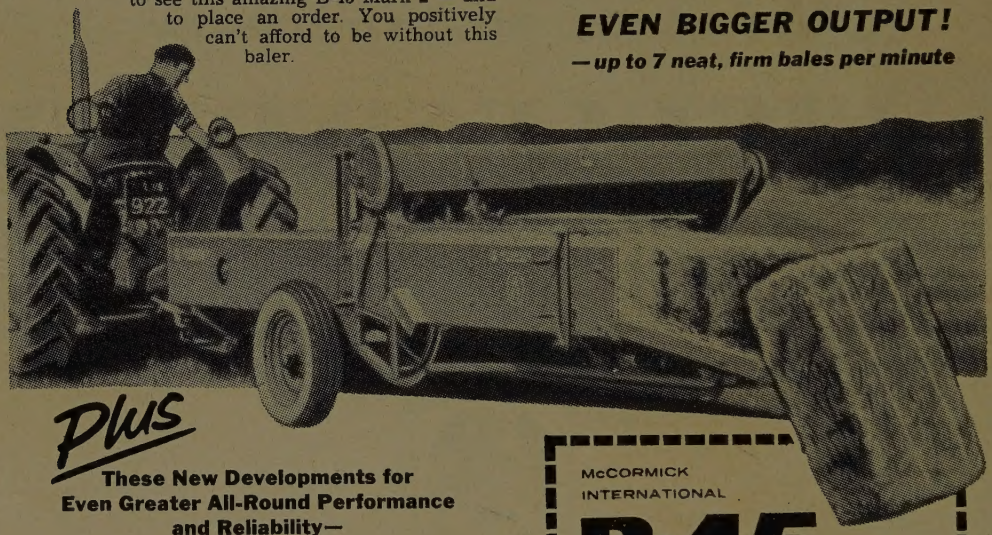

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● This was indeed a most satisfactory result and an astonishing and wonderful boost for East Africa.

THE

EAST AFRICAN AGRICULTURAL JOURNAL

Vol. XXIV—No. 4 **APRIL, 1959**

Printed and published by the Government Printer, Nairobi

Issued under the Authority of the East Africa High Commission and published every three months—July, October, January, April. Volume consists of four issues (commencing July issue)

EDITOR: D. W. DUTHIE

E.A.A.F.R.O., P.O. BOX 21, KIKUYU, KENYA

Subscription Sh. 15 per volume (Sh. 4 single copy) including postage, payable to the Editor. Subscribers are advised to remit postal orders in payment, otherwise bank commission must be added in the case of cheques.

The Editor does not hold himself responsible for opinions expressed by contributors.

Matter submitted for publication should preferably be sent through the local member of the Editorial Board. Double spacing should be used in typescript. Contributors receive 25 prints of their articles free. Additional copies may be obtained on payment if asked for in advance. Prints bear the same page numbers as the original articles in the Journal, except where, to meet a contributor's wishes, prints are supplied before publication has been completed.

Readers are reminded that all agricultural enquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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By the Grassland Research Station, Kitale, Department of Agriculture, Kenya

SUMMARY OF SPECIES OF IMPORTANT GRASSLAND PLANTS IN KENYA

Botanical Name	Common Name	Approx. Altitude range	Rainfall	Minimum seed rates for pure stands
		Feet	*Inches*	*lb. per acre*
IMPORTANT CULTIVATED GRASSES WHICH ARE IN COMMERCIAL SUPPLY				
Bromus unioloides	Rescue grass	6,500 and over	35 and over	35
Chloris gayana	Rhodes grass	0–8,000	25 and over	1½ (P.G.S.)
Cynodon dactylon	Common star grass	0–8,000	20 and over	Roots
Dactylis glomerata	Cocksfoot	7,000 and over	35 and over	10–20
Festuca elatior	Tall fescue or Kentucky fescue	7,000 and over	30 and over	5–10
Lolium italicum	Italian rye-grass	6,000 and over	35 and over	15–20
Lolium perenne	Perennial rye-grass	8,000 and over	40 and over	15–20
Melinis minutiflora	Molasses grass	5,000–8,000	25 and over	1 (P.G.S.)*
Panicum maximum var. *trichoglume.*	Slender guinea grass.	0–7,500	25 and over	½ (P.G.S.)*
Pennisetum purpureum	Elephant grass or Napier grass.	0–8,000	25 and over	Roots/stems
Phalaris tuberosa	Canary grass	6,500 and over	30 and over	5–8
Setaria sphacelata	Nandi setaria	5,000–8,000	30 and over	½ (P.G.S.)*
Sorghum almum	Columbus grass	0–8,000	20–35	15
Sorghum sudanense	Sudan grass	0–8,000	20–35	15–20
GRASSES WHICH SHOW CONSIDERABLE PROMISE FOR CULTIVATION				
Beckeropsis uniseta	Natal grass or Beck grass.	5,000–7,000	35 and over	10
Bothriochloa insculpta	Sweet pitted grass	0–6,000	20–35	30–40 (Partially cleaned heads)
Brachiaria ruziziensis	Prostrate signal grass.	3,500–6,500	30 and over	(?) 30
Cenchrus ciliaris	African foxtail or Buffel grass.	0–6,000	20–35	10–15 (cleaned)
Cenchrus setigerus	Smooth African foxtail.	0–6,000	20–35	10–15 (cleaned)
Cynodon plectostachyus	Naivasha star grass	0–6,000	20–35	5
Eragrostis superba	Masai love-grass	0–6,000	20–35	50 (heads)

SUMMARY OF SPECIES OF IMPORTANT GRASSLAND PLANTS IN KENYA—(*Contd.*)

Botanical Name	Common Name	Approx. Altitude range	Rainfall	Minimum seed rates for pure stands
		Feet	*Inches*	*lb. per acre*
GRASSES WHICH SHOW CONSIDERABLE PROMISE FOR CULTIVATION—(*Contd.*)				
Panicum colaratum	Coloured guinea grass, Blue guinea grass, or Keria grass.	0–7,500	20 and over	10–15
Panicum maximum	Common guinea grass.	0–7,500	20 and over	¼–½ (P.G.S.)*
Paspalum malacophyllum ..	—	5,000 and over	25 and over	10–15
Paspalum commersonii (= *P. scrobiculatum* var. *commersonii*).	Ditch Millet Commer grass, or Scrobic.	0–9,000	25 and over	15–20
Poa pratensis	Smooth stalked meadow grass or Kentucky blue grass.	7,500 and over	35 and over	10
Setaria splendida	Giant setaria ..	5,000–8,000	35 and over	Roots
OTHER IMPORTANT SPECIES WHICH OCCUR IN NATURAL GRASSLAND OR AS WEEDS OF ARABLE LAND				
Aristida adscensionis	Common needle grass.	0–8,000	10 and over	—
Brachiaria brizantha	Common signal grass.	0–9,000	20 and over	—
Chloris virgata	Black seed ..	0–6,000	15–35	—
Chrysopogon aucheri	Auchers grass ..	0–6,000	10–25	—
Cymbopogon afronardus ..	Blue citronella grass.	6,000–8,000	30 and over	—
Digitaria milanjiana	Woolly finger grass	0–6,000	15 and over	—
Digitaria scalarum (= *D. abyssinica*).	African couch grass.	0–10,000	20 and over	—
Eleusine jaegeri	Mafutiana or Manyatta grass.	8,000 and over	25 and over	—
Eragrostis caespitosa	Cushion love grass	0–6,000	15–35	—
Heteropogon contortus ..	Spear grass ..	0–6,000	15–40	—
Hyparrhenia cymbaria ..	Coloured hood grass.	5,000–10,000	25 and over	—
Hyparrhenia dissoluta ..	Yellow hood grass	1,000–9,000	25 and over	—
Hyparrhenia filipendula ..	Fine hood grass..	0–8,000	25 and over	—
Imperata cylindrica	Cotton grass ("Lalang" of Malaya).	0–6,000	20 and over	—
Lalipes senegalensis	Hook grass ..	0–6,000	15–35	—
Lolium temulentum	Darnel	5,000–10,000	30 and over	—
Panicum deustum	Bush guinea grass	0–6,000	20 and over	—
Pennisetum catabasis	—	5,000–8,000	20 and over	—

SUMMARY OF SPECIES OF IMPORTANT GRASSLAND PLANTS IN KENYA—(*Contd.*)

Botanical Name	Common Name	Approx. Altitude range	Rainfall	Minimum seed rates for pure stands
		Feet	*Inches*	*lb. per acre*
OTHER IMPORTANT SPECIES WHICH OCCUR IN NATURAL GRASSLAND OR AS WEEDS OF ARABLE LAND—(*Contd.*)				
Pennisetum clandestinum ..	Kikuyu grass ..	5,000–10,000	25 and over	—
Pennisetum mezianum ..	Bamboo grass ..	1,000–6,000	15–35	—
Pennisetum schimperi ..	Wire grass ..	6,500 and over	20 and over	—
Pennisetum stramineum ..	Masai grass ..	1,000–7,000	15–30	—
Rhynchelytrum repens ..	Common red top, Rosy grass, or Poverty grass.	0–10,000	20 and over	—
Setaria trinervia	Golden Setaria ..	5,000–9,000	25 and over	—
Snowdenia polystachya ..	Abyssinian grass	7,000–9,000	30 and over	—
Themeda triandra	Red oat grass ..	0–10,000	15 and over	—
IMPORTANT PASTURE LEGUMES WHICH ARE NOW IN COMMERCIAL SUPPLY				
Medicago sativa and M. intermedia.	Lucerne	0–10,000	30 and over	3–4
Melilotis alba	Sweet clover, Hubam clover or Bokhara clover.	0–10,000	30 and over	10–15
Ornithopus sativus	Serradella ..	7,500 and over	30 and over	20
Trifolium repens	White clover ..	5,000–8,500	35 and over	1–1½
Trifolium semipilosum ..	Kenya white clover.	5,000–8,500	25 and over	1–2
Trifolium subterraneum ..	Subterranean clover.	6,000–10,000	35 and over	6
Clitoria ternatea	Kordofan pea ..	0–6,000	20–40	10
Glycine javanica	Glycine	0–9,000	20 and over	5–8
Hedysarum coronarium ..	Sulla	5,000–9,000	35 and over	30
Onobrychis viciifolia (= *O. sativa*).	Sainfoin ..	7,000 and over	40 and over	30
Stylosanthes gracilis	Stylo	0–8,000	20 and over	10
Trifolium burchellianum var. *Johnstonii.*	Johnston's Clover	8,000 and over	40 and over	2
Trifolium pratense	Broad red or late flowering red clover.	5,000 and over	35 and over	10
Trifolium rueppellianum ..	Rueppells clover	5,000 and over	35 and over	10
Trifolium tembense	Tembens clover	8,000 and over	35 and over	10

*P.G.S. = Pure Germinating Seed.

Although permanent grassland is of primary importance in Kenya, reliance should largely be placed on vigorous mixed leys of grasses and legumes for the maintenance of fertility on arable land and for much of the high quality feed which is necessary for productive livestock in the mixed farming areas. Temporary leys offer the greatest scope for planned blending and utilization of the most suitable plants, but their establishment and management calls for considerable skill. It is important to distinguish between two main types of temporary ley, as the species and management for each will differ to some extent. They are, firstly, the ordinary "general purpose" farm leys which, apart from permanent pastures, provide the bulk of grazing and some hay or silage during the main rainy season and in the early part of the dry weather. Secondly, "late season" or "dry season" leys which provide a reserve of standing forage, as well as continuing to make relatively good growth, for grazing or cutting during the drier months; and which, under certain conditions, may also give an early bite at the start of the wet weather. The species for late season leys are selected for their ability to withstand drought and to maintain a fair level of quality if left as a standing reserve. Elephant grass, Sudan grass, and Star grass are already being used successfully for this purpose on a limited scale, and it is probable that other grasses such as Guinea, giant setaria, molasses grass, aand perhaps Kentucky fescue for the high altitudes will also be satisfactory.

The idea of special late season leys, although familiar in Britain (where they are known as "winter foggage") is still rather new to Kenya, and has yet to be developed where practicable in this country. It should be noted thaat they are not intended to replace hay or silage making but are regarded as complementary to the feeding of conserved fodders during the dry weather.

Establishment

There are two alternatives for the establishment of leys, underplanting seed or roots in the last crop of the arable break, or direct planting at the start of the grass break.

Underplanting may save the cost and work of some extra cultivations and generally gives earlier grazing at the start of the following season, but these advantages are likely to be offset to some extent, either by a reduction in the yield of the cover crop and the ley to begin with, or by a less satisfactory take of seedlings.

Direct planting without a grazing companion crop like oats is slower to provide grazing during the first season and may entail some extra cultivations, with the extra costs involved, but will probably result in a more satisfactory establishment of the pasture, especially where soil fertility is low and growth conditions are not very favourable.

For underplanting, some crops are generally more suitable than others; barley and wheat are both satisfactory, and maize is fair, but oats are inclined to be too smothering if left to mature. Some reduction in the seeding rate of the cereal is advantageous. Grass seeds can either be sown on the same day as the wheat or barley, or shortly after the cereal has started growth, but maize should not be underplanted before the crop is about 3 to 4 feet high, as otherwise its yield may be seriously reduced by the grass. There is an advantage in using wide row spacings of 6 to 7 feet for maize, since mechanical cultivation may be continued until a later stage, and the planting of seed or roots can safely be delayed. At wide spacings care must be taken to plant the maize sufficiently thickly in the lines so that there is no reduction below a minimum population of about 12,000 plants per acre.

When fertilizer is to be applied during establishment, and there are very few soils in Kenya which do not require it, placing it with the seed or roots is recommended rather than broadcasting, as it will thus be more easily available to the young seedlings. Generally a minimum of 100 lb. of triple superphosphate per acre should be given, and the application of a nitrogenous fertilizer may also repay use under certain conditions where very rapid establishment is desired. For general purpose leys planting close rows at a spacing of not more than 12 inches appears to be better than wider spacings, as this will encourage the rapid formation of a sward and will help to suppress weed growth as well as ensuring a satisfactory yield during the year of establishment. Late or dry season leys should be established in wider rows, as indicated in the summary, to reduce moisture competition and to facilitate cultivation if necessary.

If the drilling of seed is not possible, broadcasting can give quite satisfactory results provided that care is taken to spread the seed evenly. If the broadcasting is to be done by hand it is easier to obtain an even spread of

seed by bulking it up with a filler before sowing. It is important that the filler should be of a different colour from the soil, so that it can be seen on the ground. Materials such as sawdust, ground coffee husks, ground *boma* manure or posho can be used, but it is inadvisable to use fertilizer for this purpose if legumes are being sown, as the fertilizer may have an adverse effect on the inoculant when in such close contact with the seed.

For direct seeding it is generally better to sow the grass in a mixture with a quick-growing companion crop such as oats, which will help to reduce weed competition and which will give early grazing while the grass is coming through. Great care should be taken to avoid puddling the soil during the first few grazings before the pasture has formed a resistant turf.

Finally, there are four important points which are applicable to any method of establishment.

Firstly, it is essential to sow enough pure germinating seed per acre. Many a ley establishment has been unsatisfactory because of the failure to sow sufficient viable seed.

Secondly, inoculated legume seeds should be given a light covering immediately after sowing, as exposure to strong light kills the bacteria.

Thirdly, consolidation of the seed bed is beneficial in many areas. Rolling before, and perhaps after, sowing is therefore advisable wherever rapid drying out is a serious hazard during establishment.

Lastly, the ley will not grow vigorously on poor land which is short of phosphate and other plant nutrients. Fertilizers should be applied where necessary, and this is important not only for grass but especially for legumes if they are to make their proper contribution to the growth and quality of the pasture.

Management of General Purpose Leys

Having obtained a satisfactory establishment, the future productivity, quality and usefulness of the pasture will depend in large measure on how it is managed. Probably the most important single factor in management is rotational grazing, by which is meant grazing the pasture down when it has reached its optimum stage of growth, then removing the animals to allow the herbage to make adequate regrowth before returning the stock once again. The tendency on many farms is to bring the animals back again too rapidly before the grass has had time to build up its reserves, and this means that not only will such over-grazed pastures produce less than they should, but that the proportions between the different species within the ley may become unbalanced. Management should therefore be such as to allow the grasses sufficient time to make satisfactory regrowth between one grazing and the next, as this is essential for the vigour of the pasture.

A further point which affects the vigour of the sward is the frequency and closeness of mowing. Experimental results at the Grassland Research Station, Kitale, have shown that leys, which are frequently grazed down and mown closely, have a lower stock carrying capacity and tend to be less persistent than those which are allowed to retain a relatively tall residue or "stubble" after such grazing. Many of the grasses which are now being sown in this country are not well adapted to frequent close grazing and cutting and the blade of the machine should therefore be set high whenever mowing is necessary, generally not lower than about 7 to 8 inches if possible. However, a single close hay cut during the growing does not appear to have a very adverse effect, neither does a close mowing towards the end of the dry season, which may be necessary for tidying up the pasture and controlling weeds.

If the stocking rate is not properly adjusted to the carrying capacity of the farm, sound management becomes very difficult. Ideally stock numbers should be limited to about half way between the dry season and wet season carrying capacity of the pastures, and if this is done there is likely to be a surplus of grass during the wet weather which can be conserved for use during the drier months.

Before a system of rotational grazing can be introduced, the land must be subdivided by hedges or fences into paddocks of manageable size; and ideally the stock should not remain in the same field for more than about two weeks at a time during the growing season. Provided that there is a sufficient basis of good permanent fencing, much of the internal control can be by means of electric fences, and expenditure on fencing can be reduced by this means.

An important aspect of management is the maintenance of a satisfactory balance between the grasses and legumes, especially where white clover is a part of the next sward. Kenya white clover is now either being sown in leys or comes in naturally in many areas and, unless

the pasture is managed with care, there is often a tendency for it to grow too strongly for the grass, especially during the early life of the ley. Close mowing and frequent close grazing by cattle will favour the clover to suppress the grass; while grazing at longer intervals without close mowing will favour the grass and suppress the clover.

Management of Late Season Leys

The most satisfactory management for these specialized pastures will vary according to species and local environment, and the following suggestions should therefore be modified where necessary.

For the high rainfall seasons, take one or two grazings or a silage cut after the start of the rains. This will help to relieve pressure on the other pastures while they are making new growth and, unless carried on for too long, should not adversely affect yields later in the season. After that, close completely until a few weeks before the end of the rains (except possibly for the taking of seed) to allow time for bulky growth, then cut or graze the accumulated herbage, mow off any residue, apply fertilizers if required, and graze the regrowth (probably rationed) at intervals during the drier months.

For the low rainfall areas, there may not be time for extra grazing either after the start or before the end of the rains, and the whole growing period may therefore be required for the building up of a dry weather reserve.

The date of the first grazing after the growing period will be advanced or retarded to suit local requirements and the aim should be to use the feed before the quality falls too low, but not so early or so often as to cause a large reduction in yield during the drier months. It is possible that quality can be maintained at a fair level by using suitable legumes in the mixture. The important point is that late season leys must be given sufficient time to accumulate reserves both of leaf and root during the wet weather if they are to give satisfactory yields during the dry season.

Notes on the Important Indigenous and Introduced Pasture Grasses for use in Leys

Bromus unioloides or Rescue grass, is an introduced species which is commonly but incorrectly known in Kenya as *B. marginatus.* It produces good quality herbage for hay or grazing and a good yield. It regenerates easily by self-seeding if managed for this purpose. The approximate altitude range is 6,500 feet and over, with a lower rainfall limit of about 35 inches. (A minimum seeding rate of 35 lb. an acre for pure stands is suggested.)

Chloris gayana; Rhodes grass. Indigenous. Productive and of medium to good quality. It is probably the most important general purpose ley grass for the medium altitudes in Kenya, and is often the basic species for pastures of 3 to 4 years' duration. Approximate altitude range, sea level to 8,000 feet. It requires a well-distributed rainfall of not less than 25 inches. Suggested minimum seeding rate per acre for pure stands 1½ lb. pure germinating seed.

Commercial types of Rhodes Grass available at present; Rongai, a hardy drought resistant strain which tends to become stemmy unless it is kept grazed down and mown periodically. It is easy to establish and is recommended where soil and climatic conditions are unfavourable for the less hardy strains. Nzoia, a leafy and productive type, less drought-resistant and leafy than Rongai rhodes. Produces good quality grazing and is suggested for sowing in areas of fertile soil and a well-distributed rainfall of 35 inches a year or more.

Endebess, at present rather variable, but intermediate between Nzoia and Rongai in quality of herbage.

Cynodon dactylon: Common Star grass. Indigenous. Valuable for long-term leys or permanent pasture, but generally requires high soil fertility. Its seeding qualities are usually poor, but it can easily be propagated from root splits. In lower rainfall areas planting should be done by sodding so that the plants will have a better chance of survival. It can be established under maize or other grain crops, but direct planting of the roots, either alone or with a companion crop of oats, is probably the most satisfactory method. Periodic cleaning is necessary during establishment. Star grass retains its quality at a higher level and for a longer period than most indigenous grasses, which, coupled with good drought resistance, makes it very suitable for late season leys. Approximate altitude range, sea level to 8,000 feet. Lower rainfall limit, 20 inches.

Dactylis glomerata: Cocksfoot. Exotic. A general purpose grass of good quality for the high altitudes, depending on local soil and climatic conditions. Capable of high yields and

will persist for four years and more. Approximate altitude range, 7,000 feet and over. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 10 to 12 lb. for pure stands.

Festuca elatior. Tall fescue or Kentucky fescue. Exotic. A hardy and deep-rooted perennial, although inclined to be coarse and unpalatable. It has possibilities for use in late season leys at the higher altitudes. Drilling the seed in widely spaced rows, 3 to 4 feet apart, helps to reduce moisture competition and should result in an extension of growth into the dry months providing inter-row cultivation is carried out. Approximate altitude range, 7,000 feet and over. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre, 5 to 10 lb. for pure stands.

Lolium italicum: Italian ryegrass. Exotic. A first-class short-term general purpose ley grass which persists for about two seasons. It produces heavy yields of high quality herbage and is an excellent grass for dairy cows. It will tolerate poor drainage. Approximate altitude range, 6,000 feet and over. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 15 to 20 lb. for pure stands.

Lolium perenne: Perennial ryegrass. Exotic. A high quality grazing species for high altitudes. Its production is generally good during the first two seasons, but the yield falls off rapidly on land of medium or low fertility, but it may give satisfactory yields for three to four years if well managed and fertilized. Approximate altitude range, 8,000 feet or over. Lower rainfall limit 40 inches. Suggested minimum seeding rate per acre, 15 to 20 lb. for pure stands.

Melinis minutiflora: Molasses grass. Indigenous. Primarily a grazing grass. Much of its regrowth is made from stems above ground and its growth is therefore severely retarded by close mowing and overgrazing. The grass produces a good yield of herbage of medium quality. It is palatable and comparatively drought resistant; seeds freely; establishes well if undersown in cereal crops, and will provide useful grazing during the first dry season if established in this way; persists for 3 to 4 years and forms a good mixture with some legumes. Approximate altitude range, 5,000 to 8,000 feet. Lower rainfall limit 25 inches. Suggested seeding rate per acre ½ to 1 lb. pure germinating seed for pure stands sown in rows or broadcast. Twenty pounds of average poorly cleaned farm seed will generally be required to give about 1 lb. of pure germinating seed.

Panicum maximum var. *trichoglume*: Slender Guinea grass. Introduced. A good all-round temporary ley species; produces a good yield, although it will not stand intensive grazing for long periods, but persists for three to four years if allowed to make fair regrowth between grazings. It is comparatively drought resistant and therefore very useful for dry season grazing, but should be drilled in rows 3 to 5 feet apart to reduce moisture competition. Approximate altitude range, sea level to 7,500 feet. Lower rainfall limit 25 inches. Suggested minimum seeding rate per acre ½ lb. pure germinating seed. Twenty-five pounds of average poorly cleaned farm seed is required to give about ½ lb. of pure germinating seed.

Paspalum dilatatum: Dallis grass. Exotic. This grass is not among the best of the ley grasses as it is not sufficiently productive, but it may be useful on poorly drained soils as it tolerates wet conditions. It is very persistent and of good quality, and can withstand mild frost, but the yield is low. Commercial seed has not always been reliable, and a recent germination report is essential when obtaining seed. Establishment is slow and it is advisable to sow the seed in a cereal crop. Approximate altitude range, 6,000 feet and over. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre, 8 to 12 lb. for pure stands.

Pennisetum purpureum: Elephant grass or Napier grass. Indigenous. It is a valuable late or dry season forage grass, and produces a heavy yield of low or medium quality feed. Canes or root splits should be planted 3 feet in the rows and 8 to 10 feet apart between the rows to reduce moisture competition during the dry season and to facilitate inter-row cultivation. Couch grass may become a serious weed in elephant grass unless weed eradication is done at regular intervals.The mature roots are difficult to dig out. For maximum dry season production, it has been found best to treat the grass leniently during the growing season by taking one harvest early in the season and one towards the end of the season. This method of management allows the grass to accumulate root reserves for dry season production. Approximate altitude range, sea level to 8,000 feet. Lower rainfall limit 25 inches.

Phalaris tuberosa: Canary grass. Exotic. A productive general purpose ley grass of high quality. It is not drought resistant, but where conditions are favourable it is very persistent and can be used for long-term leys. It grows well on soils of impeded drainage, besides

flourishing on well-drained land, and is especially useful for ensiling. Approximate altitude range, 6,500 feet and over. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre 5 to 8 lb. for pure stands.

Setaria Sphacelata: Nandi Setaria. Indigenous. A vigorous tufted perennial of good quality and is very persistent under good conditions. It will not tolerate a soil of low fertility, but does well on poorly-drained land and is recommended for "vlei" soils. The seed is susceptible to "Bunt" infection. For seed production it must be grown in isolation or it will cross-pollinate with other strains of the same species. Approximate altitude range 5,000 to 8,000 feet. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre, ½ lb. pure germinating seed for pure stands.

Sorghum almum: Columbus grass. Exotic. This vigorous perennial has become popular in South Africa for its adaptability and persistence. It spreads by short underground runners, and has a useful life of four to five years and is not difficult to eradicate. It is palatable, productive and drought resistant. It is attacked by maize stalk-borer. Like many other Sorghums there is always a possibility of prussic acid poisoning, especially on young wilted regrowth, and it is therefore advisable to delay grazing until after stem formation has started. It cross-pollinates with other Sorghum varieties and for seed production it should be grown in isolation. The seed can be drilled with a maize planter using a special plate. A row spacing of 3 to 4 feet is recommended. Approximate altitude range, sea level to 8,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 12 lb. for pure stands.

Sorghum sudanense: Sweet Sudan grass. Exotic. A short-lived perennial forage grass of good quality which generally has a useful life of not more than a year. It gives good yields of hay, silage or grazing, and it is thought to be safer than most Sorghums in respect of the possibility of prussic acid poisoning. In the lower rainfall mixed farming areas it is particularly useful because of its rapid growth, easy seeding and drought resistance. It grows very well on "black cotton" soils. Sudan grass has been used successfully as a companion crop in the establishment of Rhodes grass and Nandi setaria, providing a useful silage crop after about three months. It cross pollinates with other Sorghums. Approximate altitude range, sea level to 8,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 15 to 20 lb. for pure stands.

Additional Grasses which may be used in Cultivation

Beckeropsis uniseta: Natal grass or Beck grass. Indigenous. It is moderately persistent, recovers quickly after grazing and appears to be suitable for hay if cut before the flowering stems appear, as it is one of the last grasses to flower. It produces good yields of seed and is quick and easy to establish. Approximate altitude range, 5,000 to 7,000 feet. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre 10 lb. for pure stands.

Bothriochloa insculpta: Sweet pitted grass. Indigenous. A vigorous, persistent and drought-resistant perennial. Seed production is good. It is palatable and of good quality when young and is recommended for general purpose leys or for seeding into natural grassland in some of the rainfall areas, particularly on black cotton soil. Approximate altitude range, sea level to 6,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 35 to 40 lb. of partially cleaned seed.

Cenchrus ciliaris: African foxtail or Buffel's grass. Indigenous. A general purpose ley grass where the rainfall tends to be low and erratic. It is vigorous, palatable and drought resistant. Once the seed has been collected it can be cleaned quite easily by hammer-milling it at a slow speed. A plate as for kibbled maize may be used to separate the seed from the hairs, which can then be removed by winnowing. Approximate altitude range, sea level to 6,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 10 to 15 lb. for pure stands.

Cynodon plectostachyus: Naivasha star grass. Indigenous. Suitable for sowing in long-term leys or for permanent pastures where the conditions are suitable. It requires high fertility with a warm dry atmosphere. Naivasha Star grass is more palatable and is probably sueprior to Common Star grass where both occur together. The two should not be confused as they are distinct species. Approximate altitude range, sea level to 6,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 5 lb. for pure stands.

Eragrostis superba: Masai lovegrass. Indigenous. A vigorous perennial pasture grass which has possibilities in some of the low rainfall mixed farming areas, such as parts of

Ukamba District. It is drought resistant, a good seeder, and is worth trying in the marginal mixed farming areas, especially on red soils. Approximate altitude range, sea level to 6,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 50 lb. of seeds for pure stands.

Panicum coloratum: Coloured guinea, purple guinea, or Keria grass. Indigenous. A productive and vigorous perennial for short-term general purpose leys of two to three years' duration in the marginal mixed farming areas, especially in localities which are seasonally waterlogged. Seed production is good and the seed can be harvested mechanically. Approximate altitude range, sea level to 7,500 feet. Lower rainfall limit 25 inches. Suggested minimum seeding rate per acre, 10 to 15 lb. for pure stands.

Paspalum malacophyllum: Exotic. A dense, persistent, low growing and leafy perennial, promising for use in general purpose leys, but it is slow to establish. Seed production is fair. Approximate altitude range, 5,000 feet and over. Lower rainfall limit 25 inches. Suggested minimum seeding rate per acre, 10 to 15 lb. for pure stands.

Panicum maximum: Common guinea grass. Indigenous. There are a number of strains of this grass which may be useful for late season grazing. The two most promising types are Sigor and Mackinnon Road, which are leafy, vigorous and drought resistant but are coarse-textured and do not produce much seed. Approximate altitude range, sea level to 7,500 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, ¼ to ½ lb. pure germinating seed per acre.

Paspalum commersonii: Ditch millet. Indigenous. A perennial grass for general purpose mixtures. It seeds well and is productive, palatable, persistent, and of high quality. It is recommended for sowing on over-cropped land, but it is not very drought resistant. Approximate altitude range, sea level to 9,000 feet. Lower rainfall limit 25 inches. Suggested minimum seeding rate per acre, 15 to 20 lb. for pure stands.

Poa pratensis: Kentucky blue grass or Smooth-stemmed meadow grass. Exotic. A very persistent, dense, high quality grass which is suggested for small-scale trials on poorly-drained soils. It appears to seed well in Kenya. Approximate altitude range, 7,500 feet and over. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 10 lb. for pure stands.

Setaria splendida: Giant Setaria. Indigenous. A vigorous tufted perennial of good quality, either for late season grazing or for general purposes during the rains. It requires a reliable rainfall and does best on fertile soils. It must be propagated from root splits as its seeding qualities are poor and unreliable. Approximate altitude range 5,000 to 8,000 feet. Lower rainfall limit 35 inches.

Other Important Species which Occur in Natural Grassland or as Weeds of Arable Land

Aristida adscensionis: Common Needle grass. An annual up to 2½ feet in height with erect or slightly pendant panicles. Spikelets with one floret, the latter being provided with three short awns. It is common in dry grassland, in bush, on rocky ground etc., from sea level to 5,000 feet altitude and under rainfall over 10 inches per annum. This grass is a common component of pastures and easily colonises bare ground. It is eaten by grazing animals when young but is almost unpalatable at the late-flowering and seeding stages because of its sharp seeds and stiff awns. The seeds can even penetrate the skin of sheep. A local Kenya type, *Aristida keniensis*, with looser panicles, occurs at altitudes from 4,000 to 7,000 feet under less dry conditions.

Brachiaria brizantha: Common Signal grass. An erect or sub-erect tufted perennial with the panicles consisting of a few dense spike-like racemes which often spread horizontally—hence the name signal grass. This grass occurs from sea level to about 8,000 feet altitude, and with a rainfall of over 25 inches per annum. It is a good grazing grass but is inferior to *Brachiaria ruziziensis* (*see* cultivated grasses).

Chloris virgata: Black seed. An annual, six inches to three feet in height with star-like panicles which at the flowering stage resemble those of Rhodes grass. The spikelets (seed) also resemble those of Rhodes grass; they have, however, longer hairs and are usually black at maturity. This grass occurs from sea level to about 6,000 feet altitude, in dry areas with a rainfall of 15 to 35 inches per annum. It is palatable and of high nutritive value and has been tried with some success for reseeding bare ground in dry areas.

Chrysopogon aucheri: Auchers grass. A tufted perennial forming low cushions. The panicles are small and the spikelets have plumose awns. It occurs in desert and semi-desert parts of Kenya with a rainfall of 10 to 13 inches per annum from sea level to 4,000 feet and occasionally also to 6,000 feet altitude. It is a valuable grazing grass.

Cymbopogon afronardus: Blue citronella. A tufted perennial three to seven feet in height with hard leaves which have a slight lemon scent. This grass is very common in Nyanza Province where it covers large areas in bush and open grassland at altitudes from 4,000 to 7,000 feet and under a rainfall of over 30 inches per annum. It is tough and almost unpalatable and is undesirable in pastures. *Cymbopogon afronardus* can provide good thatching and mulching material.

Digitaria milanjiana: Woolly finger grass. A perennial, with digitate panicles which occurs in several distinct forms and under a wide range of conditions, from sea level to about 6,000 feet altitude and under a rainfall of over 15 inches per annum. On black, heavy, seasonally water-logged soils it is represented by a tufted type while the creeping, stoloniferous types occur mostly on red soil. All varieties of this grass are highly valued in pastures.

Digitaria scalarum: African couch grass or Thangari. A rhizomatous perennial from a few inches to three feet in height with small panicles. It is widespread in Kenya from sea level to about 10,000 feet altitude, under a rainfall of over 20 inches per annum. This grass occurs in high altitude pastures and it is also very common as a weed of arable land under a wide range of conditions. *Digitaria scalarum* is highly palatable but usually lacks vigour for pasture purposes.

Eleusine jaegeri: Mafutiana or Manyatta grass. A perennial, forming broad and dense tufts 1 to 3½ feet in height with numerous leaves which are hard and very sharp at the margins. The panicle consists of a few dense and long spikes (racemes) which spread horizontally as in Signal grass. This species occurs at altitudes of over 7,000 feet and under a rainfall of over 25 inches per annum, in grassland, in abandoned cultivations, and it is particularly frequent in old *bomas* or on wet ground. An unpalatable grass and troublesome in pastures.

Eragrostis caespitosa: Cushion lovegrass. A small perennial 6 to 18 inches in height forming low dense cushions with numerous small purple panicles. It occurs from sea level to about 6,000 feet altitude in dry areas with a rainfall of 15 to 35 inches per annum, in bush and in open grassland. It is particularly common on the Yatta Plateau and between Embu and Kitui. This grass is well grazed and is of considerable value in pastures.

Heteropogon contortus: Spear grass. A tufted perennial 6 inches to 2 or 3 feet in height with one sided spikes provided with long awns. The awns of several ripe spikes are often twisted together. It occurs from sea level to about 6,000 feet altitude under a rainfall of 15 to 40 inches per annum and is particularly frequent at the coast and in semi-arid parts of the Southern and Central Provinces. This grass has good grazing value but becomes unpalatable at the late-flowering and seeding stages of growth, because of its sharp seeds and awns.

Hyparrhenia cymbaria: Coloured hood grass. A tall perennial 4 to 15 feet (occasionally up to 20 feet) in height with large panicles and vividly coloured spatheoles (hoods). It occurs at altitudes of about 4,000 feet to over 9,000 feet under a rainfall of over 30 inches per annum, in grassland with scattered bush, in woodland, and at forest edges. In abandoned cultivation it may form very tall and dense stands. When kept short this grass is well grazed.

Hyparrhenia dissoluta: Yellow hood grass. A tufted perennial 3 to 10 feet in height with medium size panicles provided with several long awns. It is very common in the *Combretum* woodland zone at altitudes from 4,000 to 7,000 feet and also occurs at the coast. This grass has thick stems which are not touched by cattle but as the stems are not numerous the basal leaves are readily grazed; the cattle also like the young panicles.

Hyparrhenia filipendula: Fine hood grass. A tufted perennial 2 to 5 feet in height with numerous thin stems and loose panicles provided with fairly long fine awns. It is widespread in Kenya from sea level to over 8,000 feet altitude and under a rainfall of over 25 inches per annum. This grass is well grazed when young but it is of low palatability at later stages of growth when the numerous stems become wiry.

Imperata cylindrica: Cotton grass. A rhizomatous perennial 1½ to 4 feet in height with long, straight and very hard leaves and snow-white dense panicles. It occurs from sea level

to about 6,000 feet altitude under a rainfall of over 40 inches per annum, mostly at the coast and in the Nyanza Province. This grass is also occasionally found on swampy ground in drier areas. Cotton grass grows in waterlogged grassland or, more often, as a weed of arable land or of coconut plantations. It is a tough grass which is grazed only to a very limited extent even when young.

Latipes senegalensis: Hook grass. A small tufted perennial 6 to 18 inches in height with numerous stems, short leaves, and small spike-like panicles, with hooked spikelets (seeds). This grass occurs from sea level to about 5,000 feet altitude under a rainfall of 15 to 35 inches per annum in dry bush and in open grassland, often on eroded ground. Hook grass is well grazed by cattle and sheep throughout the whole year and it has been successfully used for reseeding denuded land south of Embu. It produces seed abundantly and the seed is easy to collect.

Panicum deustum: Bush guinea grass. A tufted perennial up to 7 feet in height with thick stems, broad leaves and fairly large panicles with large spikelets. It occurs from sea level to about 5,000 feet altitude, mostly in semi-arid areas with a rainfall of over 20 inches per annum, chiefly in bush or at the edges of dry forest. A vigorous grass, well grazed when young.

Pennisetum catabasis. Mara grass. A perennial forming large dense tussocks up to 5 feet in height. It occurs on swampy ground and on stream banks at altitudes from 5,000 to 8,000 feet under a rainfall of over 30 inches per annum, and is particularly common and numerous in the Southern and Central Nyanza. This grass has very tough leaves and is unpalatable to cattle.

Pennisetum clandestinum. Kikuyu grass. Low, closely matted perennial with stolons and rhizomes. The spikes are reduced to clusters of two to four spikelets enclosed in the uppermost leaf-sheaths on branches of creeping stems. It occurs at altitudes from 5,000 to 10,000 feet under a rainfall of over 25 inches per annum and is particularly common on fresh forest soil or in well-manured *bomas*. A very valuable grazing grass which thrives on fertile soil.

Pennisetum mezianum. Bamboo grass. A tufted perennial 1 to 4 feet in height with hard wiry stems, much branched in the upper part, and bearing short dense spikes. It occurs at altitudes from 1,000 to about 6,000 feet under a rainfall of 15 to 40 inches per annum and is common in grassland on plains with black heavy soil, usually seasonally waterlogged. This grass is almost unpalatable because of its hard, wiry stems. There are, however, reports that its young growth is grazed by cattle to a considerable extent.

Pennisetum schimperi: Wire grass. A densely tufted perennial with hard wiry stems terminating in dense spikes. It is common at altitudes of over 6,500 feet and a rainfall of over 25 inches per annum, where it is often dominant over large areas of open grassland. A coarse unpalatable grass which is grazed to a limited extent only when very young. Burning may reduce the amount of this grass in the herbage in favour of Red Oat grass, but to produce this change a fairly hot fire is required.

Pemmoseti stramineum: Masai grass. A rhizomatous perennial 1 to 3 feet in height with thin, whitish spikes forming slowly spreading colonies. It occurs at altitudes from 2,000 to 7,000 feet under a rainfall of 15 to 30 inches per annum mostly on plains of black or grey soil and is particularly abundant on the Laikipia Plateau. A grass of low palatability when mature but well grazed when young.

Rhynchelytrum repens: Common red top or poverty grass. A loosely tufted short-lived perennial 1 to 3 feet in height with white or, more often, pink or purple panicles. It is widespread in Kenya from sea level to 9,000 feet altitude. This grass is common in abandoned cultivations, in grassland, on roadsides and as a weed of arable land. It often indicates that the land was formerly under cultivation. A grass of medium grazing value only.

Setaria trinervia: Golden Setaria. A tufted perennial 1 to 4 feet in height with golden or brownish-golden spikes. The tuft-bases are coated with old split fibrous lower leaf-sheaths, and in that, this species differs from *Setaria sphacelata* with which it can be easily confused. *Setaria trinervia* is widespread in Kenya from sea level to about 9,000 feet altitude under a rainfall of over 25 inches per annum. It is a grass of medium grazing value.

Snowdenia polystachia: Abyssinian grass. A tall annual or short-lived perennial with the stems branched in the upper part. The numerous spikes are on long peduncles and are arranged in large panicles. This species was introduced from Ethiopia as a fodder grass and is now found occasionally on roadsides

and as a weed of cultivation. In the Ol Kalou area it is becoming a serious weed in cereals.

Sorghum verticilliflorum: Wild Sudan grass. An annual 3 to 10 feet in height, with large panicles with long pendent lower branches. It occurs often in large colonies at altitudes below 6,000 feet, on roadsides, stream banks, abandoned cultivations, etc. This grass is grazed by cattle to a limited extent though it is said that the young growth can be poisonous. It tends to become stemmy too early and it compares unfavourably with Sudan grass to which it is closely related.

Themeda triandra: Red Oat grass. A tufted perennial 1½ to 4½ feet in height with the panicles consisting of pendent groups of spikelets with a few long awns. It occurs under a wide range of conditions, from sea level to almost 10,000 feet altitude, and a rainfall of over 15 inches per annum. At altitudes from 4,000 to 9,000 feet this grass is often dominant over large areas of grassland and is a valuable grazing species. Burning seems to encourage the spread of Red oat grass.

Notes on the Important Indigenous and Introduced Pasture Legumes in Commercial Supply

Medicago sativa and *M. intermedia*: Lucerne. Exotic. Requires a well-drained soil. It can be used either as a forage crop in pure stand, or in a mixture with grass, preferably in alternative rows with the grass. Lucerne should be grazed at the early flowering stage and appears to be more palatable then than when younger. Approximate altitude range, sea level to 10,000 feet. Lower rainfall limit for dry land lucerne, 30 inches. Suggested minimum seeding rate per acre, 5 lb. for pure stands and 3 lb. in a mixture with grass.

Melilotus alba: White sweet clover. Exotic. The annual variety is known as Hubam clover and the biennial as Bokhara. They are cultivated for forage and green-manuring and are drought resistant. Both varieties can be toxic to animals through badly made hay or silage. It seeds well and can be used in a mixture with grass. Approximate altitude range, sea level to 10,000 feet. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre, 10 to 15 lb. for pure stands.

Melilotus officinalis: Yellow sweet clover. Exotic. It is generally a biennial, but annuals also occur. It is rather more drought-resistant than the biennial white, but possibly less productive. Altitude, rainfall and seeding rates, the same as for White sweet clover.

Ornithopus sativus: Serradella. Exotic. An annual legume which is used for catch-crop grazing, green manuring and sometimes hay. It is recommended for trial on poorly drained soils. It may be grown either in pure stand, or in a mixture with grass. It seeds well and is at its most palatable stage during flowering and seed setting. Approximate altitude range, 7,500 feet and over. Lower rainfall limit 30 inches. Suggested minimum seeding rate per acre, 20 lb. for pure stands and 10 lb. for pasture mixtures.

Trifolium repens: Common white clover. Exotic. This clover originates from overseas and should not be confused with Kenya white clover, which is indigenous. Louisiana white clover and Ladino clover are two which have been grown successfully in Kenya. Louisiana white clover is a vigorous, palatable, perennial, persistent type, and is comparatively drought resistant. It will not withstand frequent heavy grazing and requires lenient management during the establishment year. It is preferable to broadcast and seed in a ley mixture to avoid overgrazing the clover, or to sow the seed in the same row as the grass. It seeds well.

Ladino clover appears to be more productive than Louisiana clover, otherwise it is similar. Approximate altitude range, 5,000 feet to 8,000 feet. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 1 to 1½ lb per acre.

Trifolium semipilosum: Kenya white clover. Indigenous. It is a productive perennial and is one of the best pasture legumes available at present for the medium altitude mixed farming areas. It is not frost resistant but is very vigorous and persistent and will withstand close grazing. Seed production is good, and yields up to 500 lb. per acre can be expected. Approximate altitude range, 5,000 to 8,000 feet. Lower rainfall limit 25 inches. Suggested minimum seeding rate per acre, 1 to 1½ lb. per acre.

Trifolium subterraneum: Subterranean clover. Exotic. It is an annual plant which is mainly used in leys and for sowing into natural grassland. The name is derived from its characteristics of partially burying its flower heads in the soil after the seed is set. This ensures annual regeneration in spite of grazing, or adverse weather conditions. Seed production is only fair under Kenya conditions and some varieties do better than others at the high altitudes. Approximate altitude

range, 6,000 to 10,000 feet. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre 6 lb.

Additional Legumes which may be Used in Cultivation

Clitoria ternatea: Kordofan pea. Indigenous. A perennial pasture plant for the low rainfall mixed farming areas. Seed production is good. It is drought resistant and palatable. Approximate altitude range, sea level to 6,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 10 lb.

Glycine javanica: Indigenous. A productive perennial twiner. It is drought resistant and very persistent. In the higher rainfall areas it can be used in mixtures with guinea grass or elephant grass for grazing during the dry season. In the lower rainfall areas it can be used in general purpose leys and for sowing into natural grassland. Approximate altitude range, sea level to 9,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 5 to 8 lb.

Hedysarum coronarium: Sulla. Exotic. A semi-erect perennial legume which does not persist for more than two to three years. It is fairly drought resistant and produces good yields of forage. It may be tried on a small scale in ley mixtures, for grazing or forage as an alternative crop to cereals within the arable break. However, it has not been extensively tested yet. Approximate altitude range, 5,000 to 9,000 feet. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 30 lb. for pure stands.

Onobrychis vicifolia: Sainfoin. Exotic. A semi-erect plant, drought resistant, and will persist for three to four years. It can be used in grazing mixtures or in pure stand for hay or silage. It is highly palatable and must be allowed to make sufficient regrowth during grazings to prevent it from being eaten out. Approximate altitude range, 7,000 feet and over. Lower rainfall limit, 40 inches. Suggested minimum seeding rate per acre, 30 lb for pure stands.

Stylosanthes gracilis: Stylo. Exotic. A semi-erect perennial herb, very drought resistant and persistent under grazing. It is quite productive but is inferior in quality to the best pasture legumes for the high rainfall areas. It may be used for drilling into the natural grassland in areas of low rainfall where some of the better quality legumes would not survive. Seed production is fairly good. Approximate altitude range, sea level to 8,000 feet. Lower rainfall limit 20 inches. Suggested minimum seeding rate per acre, 10 lb. for pure stands.

Trifolium burchellianum var. *johnstonii*: Johnston's Clover. Indigenous. A vigorous, persistent, spreading perennial plant which may become an important pasture legume at the high altitudes. It may be slow to establish and is a shy seeder. Approximate altitude range, 8,000 feet and over. Lower rainfall limit 40 inches. Suggested minimum seeding rate per acre in mixed pastures, 2 lb.

Trifolium pratense: Broad red clover. Late flowering red clover. Exotic. Broad red clover can be tried as an alternative to a cereal crop for one season within the arable break and could be used for grazing, hay or silage. Late-flowering red clover is more persistent and may be tried in short-term leys. Approximate altitude range, 5,000 feet and over. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre, 10 lb. for pure stands.

Trifolium ruepellianum: Rueppells clover. Indigenous. A quick-growing productive annual which is well suited to seasonally wet land, but is also productive on well-drained land. It may be used for a fodder catch-crop or as a green manure. It is palatable in mixture with grasses, and this increases with maturity. Seed production is very good. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre 5 lb. for pure stands.

Trifolium tembense: Tembens clover. Indigenous. An annual which is common on wet land at the high altitudes and may be used for forage or green manure. It is rather unpalatable until very mature. Approximate altitude range 8,000 feet and over. Lower rainfall limit 35 inches. Suggested minimum seeding rate per acre 5 to 6 lb. in pure stand.

Non-Leguminous Herbs

Carum carvi: Caraway. Less productive than some other species, but is said to aid digestion and to assist in the prevention of bloat. It may do well at the higher altitudes. Suggested seeding rate per acre, ½ to 1 lb..

Cichorium intybus: Chicory. A highly nutritious plant, rich in minerals, productive and drought resistant. It is the most important of the introduced herbs. It tolerates a wide range of soil and climatic conditions and will persist for three years or more in pastures. It should not be sown in pastures used for hay

as the fleshy leaves are difficult to cure. Suggested seeding rate per acre ¼ to ½ lb. in a ley mixture.

Plantago lanceolata: Ribgrass or Plantain. A persistent perennial which tolerates a wide range of conditions. It is very productive, nutritious and palatable, but is not very drought resistant. Suggested seeding rate per acre, ¼ to ½ lb. in a ley mixture.

Poterium sanguisorba: Burnet. A productive and persistent perennial, rich in minerals, but may not tolerate very acid conditions. Suggested seeding rate per acre, ¼ to ½ lb. in a ley mixture.

CORRIGENDUM

NOTES ON KENYA AGRICULTURE: IV—FRUITS AND VEGETABLES

In the October, 1958, issue of this Journal (Volume 24, No. 2, page 79) "Notes on Kenya Agriculture—IV Fruits and Vegetables", the names of the authors should read "By T. H. Jackson, T. H. Bannister, R. H. Bennison, H. R. Evans and A. H. Savile".

REVIEW

TYPES AND BREEDS OF AFRICAN CATTLE, by N. R. Joshi, E. A. McLaughlin and R. W. Phillips. F.A.O. Agricultural Study No. 37. Published by the Food and Agriculture Organization of the United Nations, Rome, 1957, 297 pages.

This book is a worthy successor to the first F.A.O. publication concerned with the types and breeds of cattle entitled, *Zebu Cattle of India and Pakistan*, and it is to be hoped that F.A.O., having now catalogued cattle in the Indian sub-continent and Africa, will continue the good work with similar studies of the cattle breeds of the other continents.

As a reference book it is important not only as a catalogue of African cattle, but because it describes some cattle breeds that are in danger of extinction or dilution by mass grading-up with other breeds; not necessarily imported from outside Africa, but usually from an adjacent region. As soon as some Governments recognise that although many indigenous African cattle may be uneconomic producers they are still a very valuable source of original genetic material, the better. This book should assist in mobilizing informed local opinion into making an effort to save some indigenous African breeds from eventual extinction.

The compiling of any catologue always produces difficulties of presentation, and it is particularly difficult to organize a rational method of presentation of cattle breeds, where over large areas the cattle do not fit into any clearly defined breed group but are intermediate between one type and another. The authors have, I believe quite correctly, compromised, and have catalogued African cattle partly on a geographical and partly on a genetic difference basis. The cataloguing is probably as complete as can be expected, information on each breed being arranged under the following main and sub headings:—

> Origin; conditions in the native home of the breed; location; topography and soils; climate; vegetation; management practices; physical characteristics of the breed; functional characteristics of the breed; performance in other areas; crosses with other breeds of cattle; sources of breeding stock and information regarding the breed.

The book is well illustrated, though some criticism might be made of the quality of the illustrations, it has an excellent bibliography and can be highly commended to all those working in the field of animal husbandry who are interested in the indigenous cattle of Africa.

W. J. A. P.

AN EXPERIMENT ON THE CONTROL OF BLOAT

By R. L. Wooldridge and W. H. S. Bellinge, Department of Veterinary Services, Kenya

(*Received for publication on 24th November, 1958*)

Bloat, for the purpose of this article, is defined as "a case where a beast has a gaseous and/or frothy distension of the rumen, causing distress and necessitating treatment orally and/or relief by using trochar and canula".

Reports from the Nakuru, Thomson's Falls and Naivasha areas of the Highlands of Kenya indicate that bloat is a seasonal problem of considerable magnitude on certain farms, causing, in some cases, severe economic loss. Normal attempts at control by such measures as changes in herd management and the provision of increased roughage in the feed appear to be less effective than might be expected and, on occasion, are difficult to operate owing to conditions peculiar to Kenya. There is evident need to find a method of prevention, which is both simple and cheap to administer to whole herds.

Sears and Reid (1955), working upon this problem in New Zealand, based their experiments upon the use of an anti-foaming agent, arachis oil. They sprayed an emulsion on to pastures which were grazed all day or strip-grazed before putting cattle out on to lush grass. They also added arachis oil to water troughs. A variation of these methods is reported (Payn, 1957) to have been tried successfully by a farmer in East Griqualand, South Africa. He added arachis oil to a daily feed for cattle and claimed that the amount of oil required to control bloat varied from 1½-9 oz. daily, according to individual susceptibility and to the type of pasture in use. The majority of the herd needed only 1½ oz. per day throughout most of the trial period. The cost of arachis oil in Kenya (28 cents for one ounce) would, however, make these methods very expensive.

At the Mississippi Agricultural Experimental Station, U.S.A., following earlier work on rumen micro-organisms as a factor in the aetiology of bloat, Barrentine, Shawyer and Williams (1956) investigated the use of chlortetracycline, oxytetracycline, bacitracine, streptomycin and penicillin for the prevention of this disease in cattle grazing Ladino clover. A single dose of procaine benzylpenicillin, given orally as a capsule or a drench proved to be the only antibiotic that provided protection.

They state, "of specific interest is the fact that penicillin was effective in low concentrations, whereas the other antibiotics were not. Penicillin is known as a narrow-band antibiotic and is effective against relatively few types of organisms as compared to chlortetracycline or oxytetracycline. This would suggest that bloat on clover may be caused by a relatively specific type or types of micro-organism. Gall (*see* Marston, 1953) stated that there is a pointed rod type of organism usually present in numbers 100 greater in animals that have bloated than in normal animals. This organism was a heavy gas producer".

A reasonably cheap form of penicillin contained in a feed supplement became available and trials were carried out with this following the work of Barrentine *et al.*

Experimental Procedure

It was considered that balling or drenching a whole herd daily was too cumbersome a method to be popular amongst farmers so it was decided to dose by including Penicillin Promix (I.C.I.), in powder form, in the food. Half a pound of Penicillin Promix contains 5 gm. of procaine benzylpenicillin (P.B.P.). Spoons delivering P.B.P. in doses of 100 mg., 50 mg., 40 mg., and 10 mg. were used and found to give a possible error of plus or minus 10 per cent.

The herd selected for the experiment consisted of 336 head of grade Ayrshire and Ayrshire X Jersey cattle, which had suffered many cases of bloat seasonally in preceding years, thirty cases in a day not being uncommon. The farm was situated in the Subukia Valley at an altitude of 7,500 ft. with an average annual rainfall of 49 in. The pastures were mainly Kikuyu grass, with, in a minority of paddocks, a small admixture of Kenya wild white clover and purple clover. A small quantity of star grass and a proportion of weeds were present in most paddocks. An important consideration, when choosing this herd, was that the owner and manager promised their full co-operation in the carrying out of all instructions relating to the experiment.

Experimental work was delayed until the usual bloat season of four to five months was

well under way. When dosing took place, Promix was mixed into a feed consisting of cobmeal, lucerne meal and oats in the approximate proportions of 14:3:3 given at the rate of 2½ lb. per animal at morning milking. Controls were allowed the same quantity of food without added drug. The treated animals were fed last to ensure that no residual Promix was taken from the feed troughs by controls or other cattle. Troughs were then cleaned out before the evening milking. Treated cattle and controls grazed together. None of the experimental cattle were yarded at any time, save immediately before milking and no extra roughage was given. Observations for bloat and daily recordings were carried out by the manager of the farm.

Before these experiments were initiated, the incidence of bloat amongst the 336 head of cattle over a period of 26 days averaged 29 cases per day.

Experiment No. 1

In this experiment, 20 cattle (group A) were each given 50 mg. of Promix twice weekly and 20 cattle (group B) 100 mg. each once weekly. Twenty cattle (group C1) were maintained as controls. Rainfall was recorded daily. These cattle were observed over a period of 59 days. Amongst group A only nine cases of bloat occurred. There were 19 cases among group B and 25 amongst the control animals.

Experiment No. 2

This experiment covered a period of 42 days, during which 20 cattle (group D) were each fed 10 mg. of Promix daily, 19 cattle (group E) were given 40 mg. each thrice weekly, 69 cattle (group F) each received 50 mg twice weekly and 46 animals (Group C2) were maintained as controls. Rainfall was recorded daily. Cases of bloat occurred as follows: in group D two cases; in group E eight cases; in group F 20 cases and in group C2 132 cases.

Experiment No. 3

Eighty-five cattle (group G) received 10 mg. of Promix each daily; 87 cattle (group C3) were maintained as controls. Rainfall was recorded daily. The experiment lasted 34 days. Seven cases of bloat occurred amongst group G and 99 amongst the controls.

Discussion

It will be seen from Table I that the best results were obtained from the smallest and most frequently administered dose of 10 mg. daily. It was noticed that when cattle treated with the larger doses became blown it was usually towards the end of the period after dosing. Cases generally were less severe in treated than in untreated animals. Cases were less severe in animals receiving treatment at any dosage level than in controls.

It was satisfactory to note that dosing with 10 mg. daily not only gave the best results but that the total weekly cost of this dosage was lower than that of any other dosage tried, i.e. 26.6 cts./animal/week.

The 100 mg. dose rendered the food somewhat unpalatable, the 50 mg. slightly less so. Cattle appeared not to notice the smaller doses.

Table I

	Group	No. of cattle	Dosage P.B.P.	Frequency of Dosage	No. of cases	No. cases per animal per period	% cases per day
Period 1: Pre-experiment 24·4–19·5 26 days	Whole farm herd	336	Nil	—	756	2·25/26	8·65
Period 2: Experiment 1 20·5–17·7 59 days.	A	20	50 mg.	Twice week	9	0·45/59	0·76
	B	20	100 mg.	Once week	19	0·95/59	1·63
	C1	20	Nil	—	25	1·25/59	2·12
Period 2: Experiment 2 18·7–28·8 42 days.	D	20	10 mg.	Daily	2	0·1/42	0·24
	E	19	40 mg.	Thrice week	8	0·42/42	1·00
	F	69	50 mg.	Twice week	20	0·29/42	0·69
	C2	46	Nil	—	132	2·87/42	6·83
Period 4: Experiment 3 29·8–30·9 33 days.	G	85	10 mg.	Daily	7	0·08/33	0·24
	C3	87	Nil	—	99	1·14/33	3·45

There was no correlation between the daily incidence of bloat and the rainfall over the previous 48 hours, although, as was to be expected, the incidence of this disease in untreated cattle tailed off at the end of the rains, as grazing became less lush. Experiments were then discontinued.

The results obtained were considered sufficiently encouraging to justify further experiments during the next bloat season. These will take the form of:

1. Massive dosing initially for one week, followed by daily small doses.

2. Mixing the drug in food in bulk and feeding in long troughs in the paddock for store cattle with no individual dosing.

SUMMARY

Experiments for the control of bloat in cattle using varying dosages and dosage intervals with Penicillin Promix fed to cattle on a farm with a high incidence of this disease are recorded. Results indicated that daily feeding of a penicillin food supplement, containing 10 mg. procaine benzylpenicillin, reduced the incidence of bloat. The cost was reasonable and the supplement easily administered. It is considered that the method warrants further experimentation to discover the optimum dosage for the maximum control of bloat.

ACKNOWLEDGMENTS

The authors wish to thank the Director of Veterinary Services, Kenya, for permission to publish this paper and Mr. D. F. Duncan and Mr. H. J. Wisby of Spring Valley Farm, Subukia, for putting their herd at their disposal and for their very great assistance and co-operation, without which this experiment could not have been undertaken.

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REVIEW

THE INSECT PESTS OF COTTON IN TROPICAL AFRICA, by E. O. Pearson, published by the Empire Cotton Growing Corporation and the Commonwealth Institute of Entomology, London, 1958, 355 pages, 8 coloured plates, price *40s.*

The book consists mainly of an account of all the important insect pests of cotton in Africa south of the Sahara. Each pest is systematically considered as regards taxonomy, distribution, description of different stages, life history, seasonal activity, nature of damage done, alternative hosts, natural enemies, factors affecting prevalence, and control. A key to the principal disorders of cotton in Africa is included, and introductory sections of the origins of the cotton plant, its cultivation, and its relationship with insect pests add considerably to the value of the work. It is a full and critical digest of information for the specialist, for whom is provided a comprehensive bibliography, but is written in such a way as to be of great practical use to the cotton grower.

With his extensive experience of African cotton entomology the author is particularly competent to write a text book on the subject. It summarizes a field previously covered only by numerous reports and papers—often inaccessible—and embodies many unpublished observations by the author and regional contributors. It is strong in ecological studies and the whole approach is very rightly on biological lines, adequately illustrated with figures, graphs and tables.

In addition to the sections on the control of each insect there is an appendix on the use of insecticides on cotton in Africa which discusses briefly the background of such applications, but urges caution in their employment. This is written by Mr. Maxwell Darling, whose contributions to certain other parts of the book are acknowledged.

W. W.

SUGAR CANE SMUT

By R. A. Robinson, Scott Agricultural Laboratories, Department of Agriculture, Kenya

(*Received for publication on 18th December, 1958*)

Sugar Cane Smut, caused by the fungus *Ustilago scitaminea* Syd., was first officially diagnosed in Kenya in 1958 although it now appears that the disease was first suspected in 1956 [17]. It is one of the more serious diseases of sugar cane and its appearance here is likely to be of some importance to Kenya sugar producers. So far it is already known to occur in five localities in Nyanza and in one locality in Coast Province.

Sugar Cane Smut is very distinctive and is easily recognized. The central shoot of the cane is transformed into a long, whip-like structure in which a fairly hard, woody core is surrounded by a powdery mass of dark, sooty spores, the whole being covered with a thin, silvery sheath or skin (*see* Fig. 1). As the disease develops, this skin ruptures and the spores are liberated. In the late stages only the woody core remains visible, but spores can generally be found by pulling away the leaf sheaths at its base. The fungus can be present throughout the plant and, apart from the smut whips, it does not show any signs of its presence in other stems of the same clump. It has been shown that setts taken from such stems may contain the smut fungus even though they appear healthy at the time of planting [14] and the subsequent crop will then be heavily smutted [18, 11]. It is thought that, sometimes, smut whips may be the result of individual infections and that the other stems of the clump would then be disease free. There is no easy means of testing setts for the presence of the fungus, however, and all setts taken from a diseased clump should be considered suspect. In fact, planting material should never be taken from a nursery that contains even one smut whip [2].

The disease is known also to attack and produce spores on certain species of wild grasses, but it is not yet known whether such alternate hosts will be of importance in Kenya, where the disease has so far been observed only on sugar cane.

There are two principal ways in which smut can spread to healthy crops. The first is by means of the black spores which occur in millions on each smut "whip". These spores can either be carried in air currents and infect any healthy cane on which they fall, or they may reach the soil and infect new setts planted in it. The spores can also be carried by irrigation water and the spread of the disease in furrow-irrigated, susceptible cane can be so rapid as to devastate the crop [9, 4]. The second means of spread is by planting setts which are either contaminated or infected by the smut fungus.

Fig. 1.—Sugar Cane Smut (*Ustilago scitaminea*): smutted shoot (after E. J. Butler)

Control Methods

Quarantine

International quarantine is the first and best method of excluding any disease which does not already occur in a country. It is true that plant import controls have failed to keep sugar

cane smut out of Kenya, but they have been responsible for some 40 years of freedom from this disease. In a young and developing country a respite such as this can be very useful.

It is all but certain that the disease was brought into Kenya by some human agency, either by deliberate, unauthorized importation of cane setts for planting, or by unintentional introduction of diseased cane material in packing, etc. It is quite certain that the disease has not come into Kenya on any canes passed through the official Plant Quarantine Station.

The dangers of unauthorized importation of sugar cane cannot be over-emphasized. There are still several important diseases of cane which do not occur in Kenya and which may prove worse than Smut if they once get here. Growers are reminded that, if they particularly wish to introduce a new variety, the law demands that they do so through their Department of Agriculture. New varieties can then be imported through quarantine and the long period of quarantine which is necessary serves to illustrate the difficulties associated with ensuring that no new diseases are brought into Kenya. New varieties, however, are being imported regularly and are released from quarantine periodically. The authorities not only import any new variety of real promise, but they make every effort to comply with any reasonable request by a grower. Any grower, therefore, who contemplates importing new cane varieties should approach the Department of Agriculture, but it should be remembered that the quarantine period for sugar cane is between two and three years [13].

Growers are also reminded that if they see any disease of sugar cane which is unfamiliar to them, they should notify the Department of Agriculture immediately, sending specimens. Outbreaks of new diseases are never easy to eradicate and any delay is likely to make the task impossible as, in fact, proved to be the case with sugar cane smut in Kenya.

Eradication

There are two aspects of eradication. National or regional eradication aims to keep a large area such as Kenya free of disease by the destruction of all diseased plants when they are first noticed. Unfortunately, when the authorities first discovered sugar cane smut in Kenya, it had already spread too extensively to make such a course practicable. Local eradication by individual farmers or estates aims to delay and, possibly, prevent a build-up of the disease in varieties which are only moderately susceptible. In Southern Rhodesia removal and destruction of the smut whips only has afforded a satisfactory control in varieties which were not highly susceptible [7], but in general, the fungus mycelium is likely to have permeated all the cane in the stool, and consequently the entire diseased stool must usually be removed if the eradication is to be successful. If it is found that there are too many diseased stools to make such a course economic, the variety should be discarded. Kenya Legal Notice No. 390 of the Plant Protection Ordinance, makes eradication of sugar cane smut compulsory in Kenya. When more information is available, similar notices are likely to be issued ordering the complete destruction of varieties which prove to be very susceptible and forbidding any new planting of such varieties.

Clean Planting Material

Setts taken from diseased stools are likely to be infected (i.e. have fungus mycelium inside them) and will consequently produce smutted canes. Similarly, setts taken from healthy stools in a diseased crop are likely to be contaminated (i.e. have smut spores on but not inside them) and will also produce smutted canes. Even when resistant varieties are grown it is essential to ensure that only clean planting material is used. Contaminated setts can be decontaminated by dipping in an organo-mercurial dip before planting. The routine dipping already used to control fungal rots is suitable for this purpose. On the other hand, infected setts cannot be disinfected by this method, as the fungus is inside the tissues and cannot be reached by the chemical. Infected setts can, however, be disinfected by soaking in hot water at 52° C. for 18 minutes [8]. The hot water treatment (52° C. for 1½ hours), used to control ratoon stunting virus [13], will thus also control sugar cane smut.

Rotation

A rotation which includes a fallow or green manure crop, such as is already practised in most areas in Kenya, is useful in starving out smut spores in the soil, because when the spores germinate in the absence of a sugar cane crop they die. Ploughing out a crop generally leaves fragments of cane which later grow and produce "rogues" and it is important to remove these if the full benefit from the fallow or green manure crop is to be

obtained. Unfortunately it is not yet known how long a period is necessary, in the absence of a sugar cane crop, to rid the soil of spores of the fungus.

Resistant Varieties

Sugar cane varieties differ greatly in susceptibility to smut and, in areas where it occurs, susceptible varieties are no longer grown. While none is known to be absolutely immune, the "very resistant" ones suffer only negligible losses.

Some varieties appear to have different degrees of susceptibility depending on where they are grown [15]. Co.421, for example, is reported to be resistant in Natal and Brazil, but susceptible in India. Smut has already been recorded on this variety in Kenya, but it is too early to observe its degree of susceptibility. Whether such differences are due to differences in environmental conditions or to the existence of different races of the smut fungus is apparently unknown.

In southern Africa, it seems that canes derived from *S. officinarum* × *S. barberi* crosses are suceptible and *S. officinarum* × *S. spontaneum* crosses are resistant. Hybrids between the two types of cross are intermediate in their reaction [10]. Resistance is believed to be due to the physical properties of the bud structure, which prevent infection under natural conditions, and it appears that it is not due to the presence of a chemical substance within the plant [6].

Factors Affecting Losses Due to Smut

While it is quite certain that smut will cause some financial loss to the Kenya sugar industry, the magnitude of this loss cannot be estimated because of the many different factors involved. The principal factors are as follows:—

Ratoons.—The progressive decline in yield with successive ratoon crops is well known. Current practice in Kenya generally allows two ratoon crops to be taken after the first planting. One of the effects of smut is to increase this progressive decline in yield. Not only will a clump which produced one diseased cane in one season produce several in the next ratoon crop, but it is also likely to have infected many other clumps. There is obviously a progressive increase of the disease and, as the fungus is systemic, harvesting the cane will not reduce the amount of disease. A further source of loss lies in the fact that it may be impossible to obtain a second ratoon crop.

Infected and Contaminated Setts.—If either infected or contaminated setts are used as planting material the build-up of the disease will be more rapid, and it may be found that even the plant crop is almost valueless. The use of clean planting material is absolutely essential so long as susceptible varieties continue to be grown.

Irrigation.—There is little irrigated cane in Kenya but, where furrow irrigation is used, the use of resistant varieties is essential. The disease can spread very rapidly in irrigation water and an irrigated, susceptible crop is likely to be devastated in one season [4].

Eradication of the Disease.—Although destruction of all smutted cane is required by law (Kenya Legal Notice No. 390 of 1958), the responsibility for such eradication lies with individual growers. Neglect in this respect will inevitably lead to greater losses due to a more rapid build-up of the disease both in individual crops and in the country as a whole.

Susceptibilities of Cane Varieties.—Sugar cane varieties are classed as "Very Susceptible", "Susceptible", "Fairly Susceptible", "Fairly Resistant", "Resistant" and "Very Resistant" to smut. Table I lists the principal varieties grown in Kenya during 1958. It also gives the acreage under each variety and its degree of susceptibility [15]. These ratings are based on experience in other cane-growing countries and, for reasons already given, may not necessarily apply to East Africa.

From Table I it will be seen that only 6 per cent of the total Kenya acreage of cane is under "very susceptible" varieties (Co.453, Co.331, Co.312, Co.301 and Co.213). It is likely that all these will eventually have to be discarded. About 60 per cent of the acreage, however, is under "susceptible" varieties (Co.432, Co.421, Co.419, N.Co.310 and N.Co.291) and, if the majority of these should also have to be discarded, considerable financial loss is inevitable.

A further 23 per cent of the Kenya cane acreage is under varieties which are believed to be "very resistant" (Co.290, M.134/32 and various POJ varieties) and these represent a potential source of considerable wealth to East Africa. Any new varieties which are imported can pass through quarantine in small quantities only and this process takes at least two years [13]. The subsequent commercial testing and "bulking up" occupies several more

years. Consequently, a new introduction cannot be of any practical importance for some considerable time. The "very resistant" varieties which are already being grown in East Africa, however, are already of proved commercial value and are available in quantity. They may thus become an invaluable reserve of planting material if the majority of the "susceptible" varieties have to be discarded.

TABLE I

Variety	*Kenya Acreage*	*Susceptibility*
Co.421	9,126*	Susceptible in India; resistant in Natal.
Co.419	6,989*	Susceptible.
Co.290	6,938*	Very Resistant.
Co. 331	1,832*	Very Susceptible.
Co.281	1,606	Resistant.
N.Co.310	1,236*	Susceptible.
Co.312	536*	Very susceptible (in India).
Co.408	119	Fairly Resistant.
Co.453	103	Very Susceptible.
Co.301	42*	Very Susceptible.
N.Co.291	31	Susceptible.
M/134/32	30	Very Resistant.
Co.213	22	Very Susceptible (in Rhodesia).
POJ.2961	18	Very Resistant.
Co.432	14	Susceptible (in Rhodesia).
B.3172	11	Resistant.
POJ.2714	9	Very Resistant.
Co.270	8	Fairly Resistant.
POJ.2727	5	Very Resistant.
POJ.2747	3	Unknown.
Co.434	1	Resistant.
Co.417	1	Fairly Susceptible.
POJ.2725	1	Very Resistant.
POJ.2822	1	Unknown.
POJ.2878	1	Very Resistant.
Miscel.	582	Variable.
Total acreage	29,265	

* Smut already found on this variety in Kenya. In each instance only a few diseased canes have been seen.

In conclusion, it should be mentioned that the world history of this disease involves a series of new outbreaks followed by their eventual suppression through the use of resistant varieties. This pattern has occurred in Southern Rhodesia [3, 4], Mauritius [12, 16], Argentine [5, 9], Paraguay [1] and other countries. In Tucuman, Argentina, where sugar is the principal source of local wealth the very vigorous measures adopted at the first outbreak of smut led eventually to a production higher than in any previous year [5]. It seems, therefore, that the Kenya sugar industry may be faced with a somewhat difficult readjustment period, during which all varieties which prove susceptible will have to be discarded and replaced by resistant ones. If the problem is tackled energetically, however, the appearance of smut need cause little serious dislocation of the Kenya sugar industry and there is no reason why the disease should not eventually become relatively unimportant. At present, however, while susceptible varieties continue to be grown, the disease must be regarded seriously.

ACKNOWLEDGMENTS

The cane susceptibility ratings listed in Table I were kindly supplied by G. M. Thomson, Pathologist of the South African Sugar Association Experiment Station at Mount Edgecombe, Natal. Other data in Table I were supplied by Mr. S. S. Gill and Mr. R. A. Sands, of the Kenya Department of Agriculture. Dr. G. R. Bates, Chief Botanist and Plant Pathologist of the Central African Federation, kindly supplied information on cane smut in that country. Dr. H. H. Storey and Dr. F. M. L. Sheffield, of the East African Agricultural and Forestry Research Organization, supplied information on the various aspects of cane quarantine, and Dr. F. M. Roberts gave valuable assistance in the drafting of the paper. These contributions are gratefully acknowledged.

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"INSACK"' TREATMENT OF MAIZE WITH INSECTICIDE FOR PROTECTION AGAINST STORAGE PESTS IN UGANDA

By T. H. Coaker, Empire Cotton Growing Corporation, Cotton Research Station, Namulonge, Uganda

(*Received for publication on 5th November, 1958*)

At the Cotton Research Station, maize production is an integral part of the farming system. It is grown, on the first and third year of the rotation on the main rains, between early February and June. In order to facilitate the timely planting of the cotton on the same land, immediately following maize, the latter is harvested as soon after maturation as possible when the moisture content of the grain is as high as 25 per cent. If the maize is to be stored satisfactorily and kept free of insect pests, it must be dried to a moisture content of at least 12 per cent. Local environmental conditions make natural drying in the field or crib unreliable and artificial drying, carried out at Namulonge on an "insack" platform dryer (Hutchinson *et al.*, 1958), is necessary.

During the early development of the station, maize production was small in comparison with the present annual crop of 100 tons, and the dried maize was treated with insecticide in a hand-operated rotary seed-dressing drum. Afterwards it was stored in bulk in open-topped wooden bins of approximately 2 tons capacity. Increased production made this method extremely laborious, and a method for treating the dried maize in the sack was devised so as to minimize labour requirements for this operation, and to provide an efficient method for protection of the grain against storage pests for the greater part of the following year.

Previous attempts to treat grain in the sack with pressure injectors has not proved wholly successful due to the very poor distribution of the dust obtained (Oxley, 1950, LePelley, *et al.*, 1955).

In this paper two experiments are described, which were carried out in the development of an "insack" method of maize treatment, together with a description of the apparatus used.

Methods of Treatment

After the maize had been dried in the sack to 12 per cent moisture content it was treated with gamma B.H.C. dust (as Lindane) by either of the following methods:—

(1) By mixing with loose maize, 150 lb. at a time, for two minutes in the hand-operated rotary drum (44 gal. capacity).

(2) By injection into six places in the sack, one at each corner and one on either side of the centre, with a pressure injector gun (*see* Plate I) operating between 6 and 8 lb. per square inch air pressure. The sack was then tumbled into the rotary mixer (*see* Appendix for detailed description) at six revolutions per minute for four minutes. An important feature was that the maize, after being thrashed wet was bagged and the bag sewn up. The shrinkage and loss in weight from the drying produced a partially filled sack, approximately 150 lb. of maize in a 200 lb. sack. The effect of the partially filled sack allowed the maize grains to move freely within the sack as it was tumbled, thus aiding in the distribution of the insecticide.

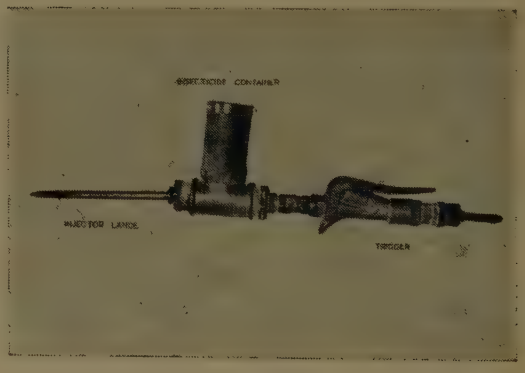

Plate I.—Injector lance for insack treatment with insecticide dust

The period of rotation for the "insack" mixing was determined by injecting dust, impregnated with methylene blue, into a sack of maize and then tumbling it for a predetermined period in the rotary mixer. The sack was then carefully cut open and the distribution of the dust observed. Good distribution of the dust was obtained after the sack had been tumbled for two minutes or more, with no apparent concentrations of the dust remaining at the points of injection.

Storage Methods

(*a*) In open-topped wooden bins of approximately 2 tons capacity.

(*b*) In stacks of sacks; the sacks were not filled to capacity but were stacked immediately after the insecticide treatment.

All the treatments were housed in the same granary that had previously been disinfested of insect pests.

Sampling Methods

Samples of grain were taken at monthly intervals from (*a*) the bins, using a bulk sampler at 18 and 36 inches depth from five scattered points over the surface of each bin, and from (*b*) the stacks, using a 12-inch sampling spear and sampling ten sacks from each stack, with three samples taken along the length of each exposed sack. In each case a sample of approximately 3 lb. of maize was taken. The samples were then examined for numbers of adult insects. Statistical analysis showed that the number of samples taken from each treatment were sufficient to demonstrate the reality of differences between all levels of the insect populations.

A similar quantity of the maize was taken from each sample and sorted into damaged and undamaged grains, and the mean weight of 100 damaged and 100 undamaged grains recorded. From this data percentage losses in weight were calculated. The final percentage loss in weight, illustrated in Tables I and II, probably underestimates the actual loss in weight, since the loss from broken grains was omitted from the calculation. However. the difference would have been small since only approximately 2 per cent by weight of the total grains were broken. The broken grains were caused by thrashing.

Experiment 1

This experiment was carried out primarily to compare the treatment and storage methods described. Maize treated in the hand-operated drum was stored in open-topped bins and the maize treated by the "insack" method was stored both in the bins and in the sack. The insecticide was applied at 1.5 per cent gamma B.H.C. dust at rates of 1, 2 and 4 p.p.m. of active ingredient to the weight of grain.

Each treatment comprised three bins of maize or 6 tons of maize stacked in the sack. One untreated stack and three untreated bins were included as control treatments.

Results

The insects present in order of numbers found were:—

1. *Calandra oryzae L.*
2. *Oryzaephilus mercator* Fauv.
3. *O. surinamensis L.*
4. *Ephestia cautella* Walk.
5. *Tribolium casteneum* Herbst.
6. *Araecerus fasciculatus* Deg.
7. *Ahasverus advena* Waltl.

Of the pests listed, *C. oryzae* was the first to infest all the treatments, being found one month after the commencement of storage. No adults were found immediately after treatment, and probably came in from the field within the grain as eggs or larvae, later infesting the

Table I.—Percentage Grains Damaged and Loss in Weight at Final Sampling from Experiment 1

Treatment	Months of		Per cent Damaged Grains	Per cent Weight Loss
	*Effective Control	Observation		
Drum Mixing, Bin Storage—				
1 p.p.m.	10	10	6	1
2 p.p.m.	10	10	4	1
4 p.p.m.	10	10	5	1
Insack Mixing, Bin Storage—				
1 p.p.m.	2	3	—	—
2 p.p.m.	10	10	5	1
4 p.p.m.	10	10	2	1
Control	0	3	—	—
Insack Mixing, Insack Storage—				
1 p.p.m.	0	3	5	1
2 p.p.m.	6	9	18	3
4 p.p.m.	6	9	12	2
Control	0	3	—	—

*Months of effective control continued until the treatment no longer restricted the increase of storage pests.

TABLE II.—PERCENTAGE DAMAGED GRAINS AND LOSS IN WEIGHT AT FINAL SAMPLING FROM EXPERIMENT 2

TREATMENT	MONTHS OF		SAMPLING FROM OUTSIDE OF STACK		SAMPLING THROUGHOUT STACK	
	Effective Control	Observation	Per cent Damaged Grains	Per cent Loss in Weight	Per cent Damaged Grains	Per cent Loss in Weight
INSACK MIXING AND STORAGE						
0·5 *per cent of B.H.C.*						
1 p.p.m.	6	10	18	3	12	2
2 p.p.m.	6	10	12	3	11	2
4 p.p.m.	6	10	19	4	9	2
1·0 *per cent of B.H.C.*						
1 p.p.m.	4	6	24	5	11	2
2 p.p.m.	4	6	14	4	11	2
4 p.p.m.	4	8	17	3	10	2
1·5 *per cent of B.H.C.*						
1 p.p.m.	4	6	22	8	19	3
2 p.p.m.	4	6	31	9	17	4
4 p.p.m.	4	6	16	3	16	4
DRUM MIXING AND INSACK STORAGE						
0·5 *per cent of B.H.C.*						
1 p.p.m.	9	10	6	1	2	1
2 p.p.m.	9	10	7	2	1	1
4 p.p.m.	9	10	9	1	2	1
1·0 *per cent of B.H.C.*						
1 p.p.m.	9	10	4	1	5	1
2 p.p.m.	9	10	2	1	3	1
4 p.p.m.	9	10	5	2	2	1
1·5 *per cent of B.H.C.*						
1 p.p.m.	5	6	15	3	11	1
2 p.p.m.	5	6	8	2	6	2
4 p.p.m.	5	8	17	3	9	2

treatments. The population of *Oryzaephilus* spp.. increased slowly, but after six months was found in almost equal numbers to *C. oryzae* in most of the treatments. The remaining pests listed were only occasionally found and were more common in the maize stored in the sack than in that stored in the bins.

Both the number of *C. oryzae* and the percentage of grains damaged were used to determine the efficiency of the treatments, and once it became obvious that an insecticide treatment was not controlling the storage pests it was discarded for economical reasons.

The numbers of adult *C. oryzae* sampled during the storage period are illustrated in Fig. 1, and the final damage and calculated loss in weight in Table I. The results illustrate the effectiveness of the bin storage treatments, particularly following insecticidal mixing in the hand-operated rotary drum, when all rates of gamma B.H.C. were effective for ten months. The untreated control treatment was discarded after three months following a rise in insect numbers. The "insack" mixing and storage treatments lost their effectiveness in the 2 and 4 p.p.m. gamma B.H.C. treatments after seven months but were maintained under observation for nine months as shown in Fig. 1. The 1 p.p.m. gamma B.H.C. treatment proved no more effective than the control treatment. However, in the treatment containing the higher rates of insecticide, final damage and

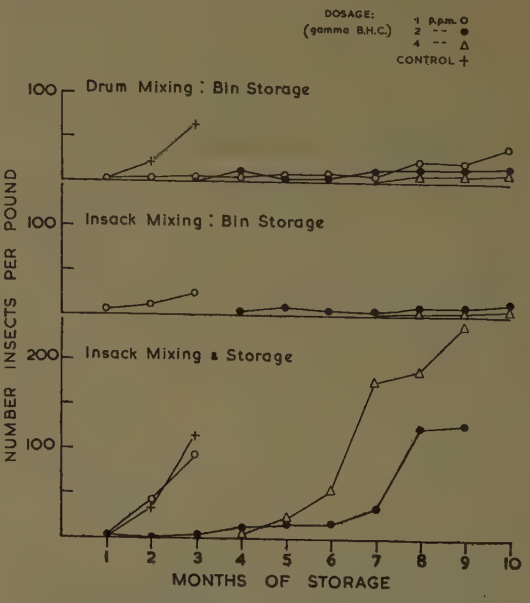

Fig. 1.—Number of *Calandra oryzae*: adults alive per pound in Experiment 1

loss in weight were not severe. Bin storage following "insack" mixing proved as effective as mixing in the drum, both for the 2 and 4 p.p.m. treatments.

The better insect control obtained by the bin entirely from a greater residual effect of the insecticide than in the "insack" storage treatments, since the bins were not air-tight, having one surface freely exposed to the atmosphere, and were also of smaller bulk than the maize stored in the sack, i.e. 2 tons as opposed to 6 tons. It appeared that the better treatments were achieved as a result of the more efficient distribution of the active ingredient throughout the maize, giving a better control of storage pests. The necessity for efficient distribution of the insecticide was investigated in the succeeding experiment.

Experiment 2

The two methods of treatment were the same as in Experiment 1, but in this experiment all the maize was subsequently stored in the sack. The insecticide was mixed at three rates of 1, 2 and 4 p.p.m. for each of three concentrations of gamma B.H.C. dusts, i.e. 0.5 per cent, 1.0 per cent and 1.5 per cent. With the lower concentration dusts, the greater volume added to the grain to give the required rates of gamma B.H.C. would also contribute to the better distribution of the active ingredient. Each treatment comprised 1 ton of bagged maize (15 × 150 lb. sacks) stacked separately, constituting 18 treatments, together with one untreated stack as the control treatment. Each stack was lightly dusted on the surface with a mixture of 1.5 per cent gamma B.H.C. and 5 per cent D.D.T. dusts in equal proportions, to prevent undue contamination by pests from one treatment with another. As in the previous experiment each treatment was discarded when it showed signs of failing.

Results

The species of insects found were as recorded in the previous experiment in the same order of importance. However, *Oryzaephilus* spp. were far less affected by the insecticide. treatment than in the previous experiment, and reached high numbers in the later stages of the experiment* (*see* Fig 2). The numbers of *C. oryzae* recorded throughout the storage period are illustrated in Fig. 2, and the final damage and loss in weight in Table II. The best control of storage pests was obtained from the treatments mixed in the hand-operated rotary drum with the low-concentration gamma B.H.C. dust. This result supports the hypothesis that good distribution of the dust throughout the grain is necessary to produce the best protection against storage pests. Of the "insack" mixing treatments the low-concentration dusts, namely 0.5 per cent gamma B.H.C. maintained satisfactory control of the pest for ten months, resulting in a low damage rate and weight loss.

In order to compare the insect population sampled with a 12-inch spear from the outside of the stack, with the population throughout the complete stack, each sack was sampled with a 3-feet walking-stick sampler across the diagonals of the sack when the stack was finally broken down. The relationship between the two methods is illustrated in Fig. 3, where the regression line between the number of *C. oryzae* sampled by each method is shown. The results indicate a greater concentration of the insect on the outside of the stack, thereby giving an over-estimate of the total population throughout the stack. The same considerations apply to the number of grains damaged. A statistically significant relationship was obtained between the percentage of grains damaged and the calculated percentage loss in weight (*see* Fig. 4).

Conclusions

The two experiments described demonstrate that even after the grain has been well dried insecticidal treatment is necessary in order to store maize for any length of time under the local conditions in Buganda.

When the maize is brought in from the field it shows little or no insect damage and few storage pests. Therefore, providing that a satisfactory control measure is applied soon after the grain has been dried, it is possible to keep it in good condition throughout the greater part of the following year. The method described for treating maize in the sack, with a low-concentration gamma B.H.C. dust (as Lindane), proved successful with little resultant damage or loss in weight to the grain within a ten months' storage period. However, towards the end of the storage period the total insect population was high, particularly the numbers

* Davies (1958) has found in preliminary experiments that gamma B.H.C. dust, up to 4 p.p.m. active ingredient, has no effect on the breeding rate of both species of *Oryzaephilus*.

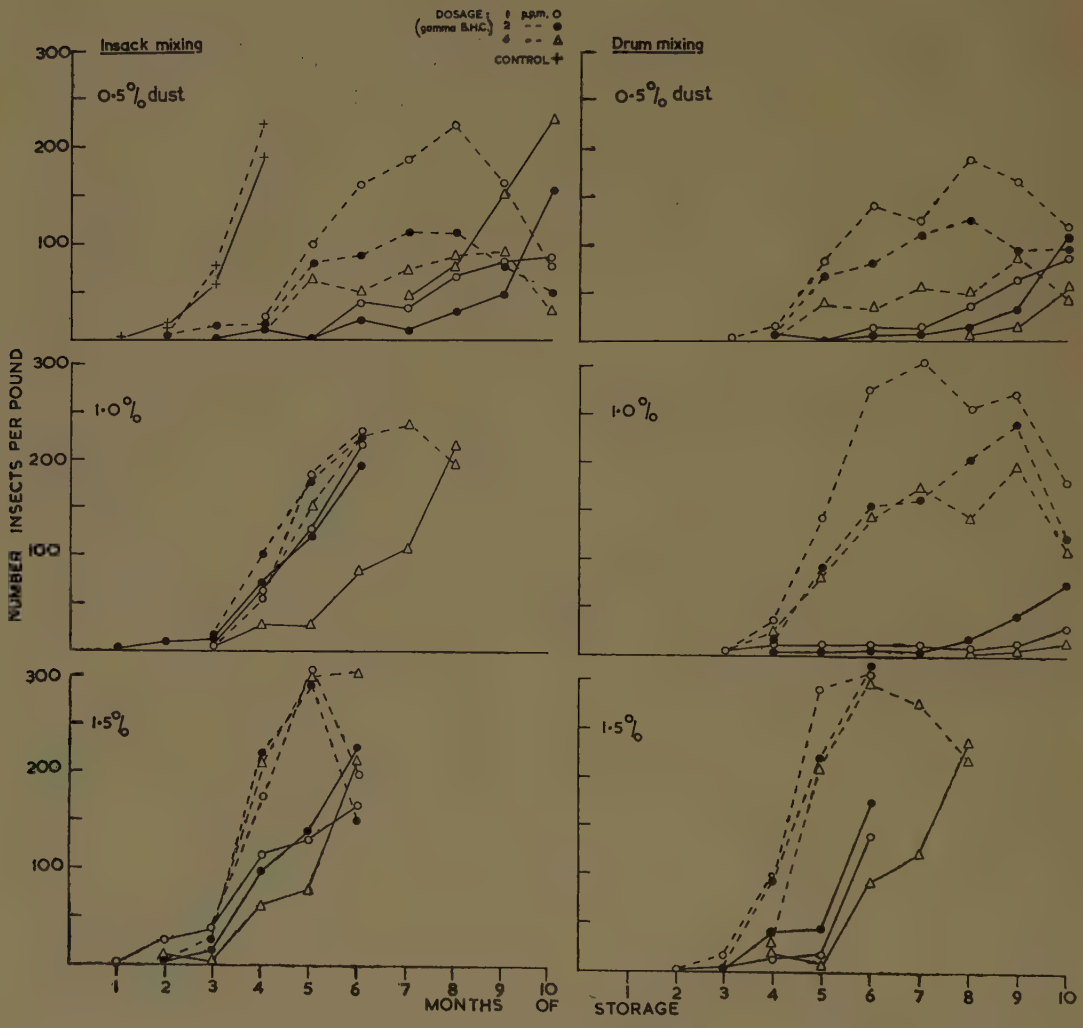

Fig. 2.—Number of *Calandra oryzae* (Unbroken line) and *Oryzaephilus spp.* (dotted line): adults alive per pound in Experiment 2

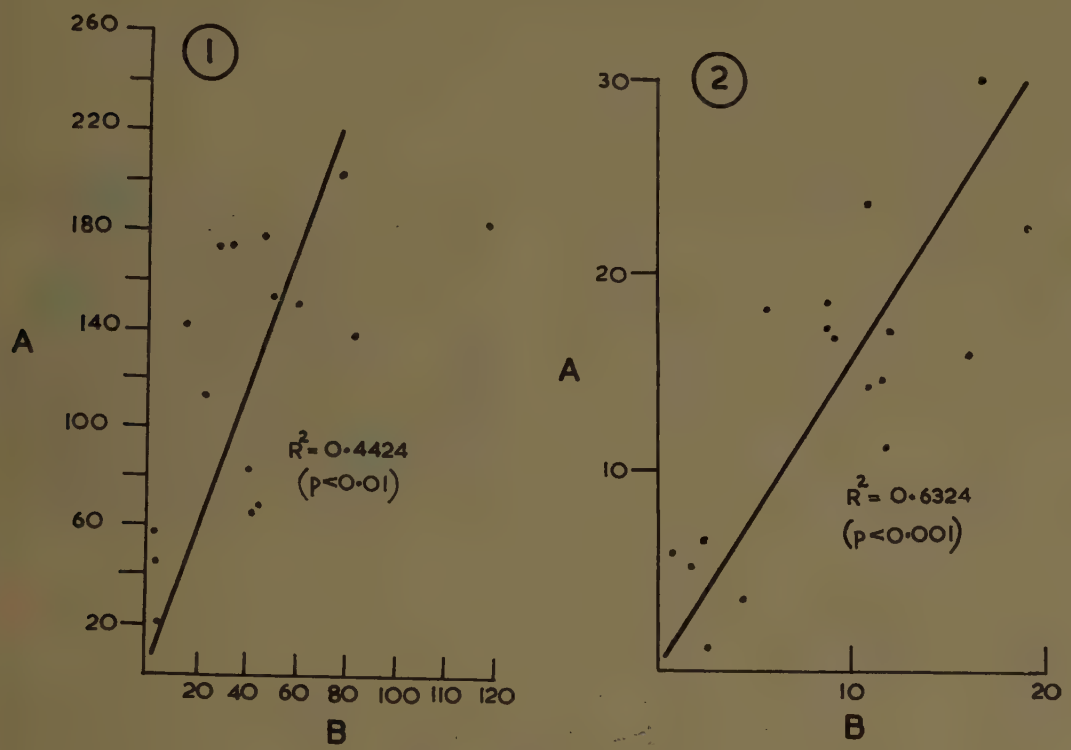

Fig. 3.—Relationship between:

(1) *Calandra oryzae*;

(2) Grains damaged;

when sampled from the outside of the stack with a 12-in. spear (A) and when sampled throughout the stack with a 3-ft. spear (B). From Experiment 2

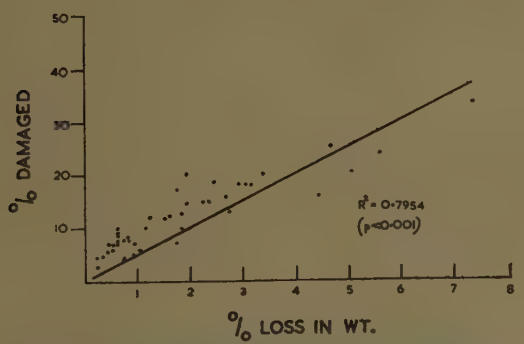

Fig. 4.—Relationship between percentage damaged grains and calculated percentage loss in weight, from Experiment 2

of *Oryzaephilus* spp., but this insect did not appear to cause direct damage or serious loss in weight to the grain.

It is suggested that a good distribution of the insecticidal dust throughout the maize is necessary to prevent a serious insect infestation. Although the "insack" treatment method was not as efficient as the hand-operated rotary drum method in mixing the insecticide with the grain, as indicated by the resultant efficiency of storage, it is a more practical method when treating a large quantity of maize. It is also possible that when storing larger bulks of sacks than were used in the experiments, together with occasional applications of insecticide to the outside of the stacks, better storage conditions would result.

Summary

A new method for treating maize with insecticide in the sack is described.

A comparison of maize treatment and storage methods suggest that to obtain the best results from insecticidal treatment of grain, good distribution of the dust throughout the maize is necessary, prior to storage in bulk or sacks.

Maize treated with 0.5 per cent gamma B.H.C. dust at 1, 2 and 4 p.p.m. by the "insack" method remained in good condition, with little damage from storage pests, for ten months.

Acknowledgments

Acknowledgment is due to Mr. H. G. Farbrother for designing and constructing the injector gun and rotary "insack" mixer. Thanks are also due to him and Mr. J. C. Davies for their help and interest during the experiments.

Appendix

The Rotary "Insack" Mixer (*See Plate II*)

Five unserviceable tractor tyres (size 14 × 32) are bolted together to form a "cylinder" 6 ft. long with an internal diameter of 31 in.

The tyres are supported by two fabricated rollers, each 12 in. in diameter. One roller is belt-driven through a gear at approximately 30 r.p.m by a 1-h.p. electric motor. The cylinder formed by the tyres is rotated by friction at 6 r.p.m.

Plate II.—"Insack" Rotary Mixer

Mounted along the inside of the tyres are a series of curved iron skids set at an appropriate angle to the axis of the cylinder, which gradually drives the sacks along the cylinder during rotation. The cylinder is sufficiently long to take three 200-lb. sacks lying end-to-end at one time. At the rotation rate described one sack moves along the total length of the cylinder and is discharged at the far end in approximately four to five minutes. As one sack is discharged so another sack previously injected with insecticide is placed into the cylinder. The throughout rate is approximately three bags or 4,500 lb. of maize per hour.

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THE FOOD PROPERTIES OF FLINT AND DENT MAIZE

By R. T. Ellis, Department of Agriculture, Nyasaland

(*Received for publication on 4th November,* 1958)

In deciding the policy for maize breeding in Nyasaland the question of whether to breed for a flint or a dent maize was of first importance.

The essential difference between these two types is in the distribution of areas of different density of starch granules in the endosperm tissue of the grain. Where the granules are tightly packed the tissue is hard and corneous and does not shrink on drying. Where the granules are less dense the tissue is softer and floury and shrinks on drying.

In flint maize the hard endosperm comprises most of the grain and forms a cap over the germ. In dent maize the hard endosperm is present only as an open cylinder which partly surrounds the germ towards the base of the grain. The cap is composed of the softer endosperm which shrinks towards the middle producing the dent in the grain.

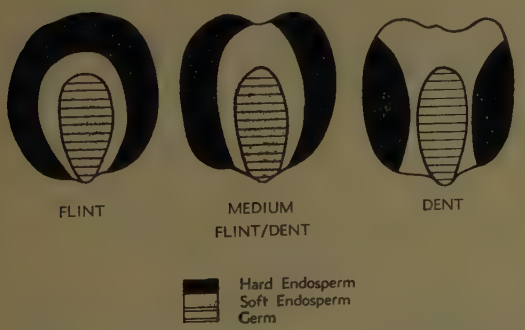

Diagram of longitudinal section through maize grains

The great majority of varieties and hybrids in commercial use in the great maize-growing areas of the world are dent. In the U.S.A. and in South Africa for instance flints are only grown in areas where dents do not mature due to a short growing season. In Southern Rhodesia the commercial hybrids and popular open pollinated varieties are exclusively dent.

In Nyasaland, however, the local maize grown by Africans is predominantly flint. All types do occur from the pearl-like extreme flints, through those with a small dimple where there is a small cap of soft endosperm, to ones with a distinct cap of soft endosperm and a large dent. These dents however are not common and only appear as odd ears in a flinty mixture. A pure dent large-seeded variety of maize such as "Hickory King" is known to the African as "Bera". This word is thought to be a corruption of Beira, the port through which at various times of famine dent maize has been imported on a large scale.

The highest yielding commercial hybrids and varieties so far tested by the Department of Agriculture in Nyasaland have been dents and there is reason to believe that high cob yields and a high shelling-out percentage is associated with dent rather than with flint grains.

Sheer yield at harvest is not however the only consideration in choosing a variety. In Nyasaland two other factors which are of great importance are resistance to insect damage during storage and local preference.

In African peasant agriculture in Nyasaland the cobs are stored complete with husks, thus considerable resistance to initial infestation by moths and weevils is conferred by the presence of thick husks which are long enough to cover the tip of the cob completely. This is a character possessed by the local maize and one which it is essential that any improved variety should have.

The best husks do not prevent the entry of weevils indefinitely, however, and then the rate at which the insects work through the grain is determined by its hardness. Dr. Salmond, the Research Entomologist who worked in Nyasaland considered that twice as much damage was incurred by dent as by flint maize (Salmond, 1954). Eden (1952) concluded that there was a direct relationship between the amount of weevil damage and the hardness of the grain.

The Africans of Nyasaland definitely prefer flint to dent, partly because they know that the former stores better but mainly because of the belief that it is superior for the preparation of maize flour by their traditional method. This method is described in detail by Williamson (1955). The main steps in the process are as follows: The grain is made wet and is pounded with a pole in a wooden mortar. This removes the skin (pericarp), the germ and also some of the soft endosperm and these tissues

are winnowed off as bran or *madeya* from the remaining endosperm which is known as the *mphale*. The *mphale* is then soaked for several days to soften it and is then pounded into fine white flour called *ufa*. Even after prolonged pounding there still remains a small proportion of very hard particles which are separated from the flour when poured through very fine wire mesh sieves. This is known as the *nsece, misere* or *mitama* and is cooked as a gruel which forms a light meal at odd times of the day. *Ufa* when boiled with water makes the stiff porridge which is the staple diet of the country. When food is plentiful the *madeya* is thrown out to be eaten by chickens and other domestic animals. In times of food shortage however it may be re-sorted and the fine particles containing much of the germ used for mixing with *ufa*. Nursing mothers and those going to do hoeing sometimes eat this by choice as it is said to be more sustaining. In times of real famine all the *madeya* is eaten or used for making beer. On the whole however, and especially in areas where maize is plentiful, the *madeya* is regarded as a waste product. *Madeya* is said to give an unpleasant taste to the porridge and the same applies to that made with the whole-meal flour ground in a mill and known as *mgaiwa*.

The women who do the pounding say that dent maize gives a much higher proportion of *madeya* to *mphale* than does flint; when questioned some gave estimates as high as twice as much. It was therefore decided to investigate the matter quantitatively.

Ten women chosen at random, all wives of employees on the Agricultural Research Station, Chitedze, agreed to co-operate in the experiment described below. Each woman was given 3,000 gms. of each of the following varieties of maize. A. Pure flint "Chitedze Hybrid No. 2", B. Medium flint/dent "Namalenga", C. Pure dent "Southern Rhodesia Hybrid No. 1". In their houses and using their own utensils they prepared from the three samples the *mphale* and *madeya* which were brought to the laboratory for weighing. The *mphale* was then returned to the women for making into *ufa* and *nsece*, these fractions being brought in again for weighing. At all weighings moisture percentages were carefully determined by means of a Marconi electric meter and all weights were corrected to dry weights. The corrected data was analysed statistically and very consistent results were obtained as can be seen from the very low coefficients of variation resulting (*see* Tables I and II).

TABLE I.—CORRECTED DRY WEIGHTS (GMS.)
(*Means of* 10 *samples*)

	A Flint	B Medium Flint/Dent	C Dent
Original grain ..	2,454	2,460	2,445
Madeya	630	695	944
Mphale	1,820	1,770	1,467
Ufa	1,537	1,531	1,227
Nsece	137	93	93

TABLE II.—PERCENTAGES OF FRACTIONS

	A Flint	B Medium Flint/Dent	C Dent	Coef. of Variation	Least significant difference
Mphale of original	74·2	72·0	60·0	2·7	0·5
Madeya of original	25·7	28·3	38·6	2·9	0·5
Madeya of Mphale	34·6	39·3	64·3	10·0	6·1
Ufa of original ..	62·6	62·2	50·2	3·7	0·6
Ufa and Nsece of original ..	68·2	66·1	54·0	2·9	0·5

The ten samples of *madeya, ufa* and *nsece* from each of the original varieties were bulked, and samples were analysed by the Agricultural Chemist at this station. The results are given in Table III.

TABLE III.—CHEMICAL ANALYSIS

	A Flint	B Medium Flint/Dent	C Dent
	MADEYA		
% Oil	14·12	11·89	7·87
% Protein.. ..	11·73	11·21	10·04
% Fibre	5·83	5·75	5·27
% Carbohydrate ..	61·16	67·95	74·34
% Ash	3·16	3·20	2·48
	UFA		
% Oil	1·15	1·19	0·58
% Protein.. ..	7·19	6·99	5·83
% Fibre	0·63	0·67	0·68
% Carbohydrate ..	90·63	90·55	92·64
% Ash	0·40	0·60	·27
	NSECE		
% Oil	0·90	0·27	0·22
% Protein.. ..	11·37	10·59	8·87
% Fibre	0·88	0·82	2·19
% Carbohydrate ..	87·19	87·99	88·49
% Ash	0·47	0·42	0·73

This experiment completely justifies the African's preference for flint maize. The results indicate that for normal purposes he will obtain 12 per cent more flour and 14 per cent more usable material—when *nsece* is included

—from an equal weight of flint maize as compared with dent. These proportions may be much larger too when weevil resistance is considered, as damaged grains are discarded at the first pounding.

Ufa, nsece and *madeya* from flint grains is also richer in oil and protein than that from dent.

The variety Namalenga selected as a medium flint/dent is seen to be much nearer to the flint than to the true dent.

This underlines the fact that in varietal selection yield alone cannot override considerations of quality in relation to use and justifies the Department's policy in the present circumstances of breeding for a flint type of maize.

It will be noticed that the *madeya* contains 37 per cent of the protein and 84 per cent of the oil in flint maize and 55 per cent of the protein and 91 per cent of the oil in dent maize. It might appear at first sight that much valuable food material is in this way discarded. Experience has shown, however, that a change over to a diet of whole-meal maize flour where this provides 80 per cent or more of the total calories may result in malnutrition and the incidence of deficiency diseases such as Pellagra. The food made from whole-meal flour is less palatable and by virtue of its high fibre content is very much less digestible than than made from *ufa*. Also during the soaking of the grain in the preparation of *ufa* chemical changes take place which release nutrients which remain unavailable to the body if the grain is milled dry. These matters have been studied by the Nutrionists of the Applied Nutrition Unit of the London School of Hygiene and Tropical Medicine and they have concluded that unless the diet contains ample supplies of meat, fish groundnuts and fresh vegetables the use of *ufa* is definitely preferable to that of dry-milled whole grain (*mgaiwa*).

There has been an enormous increase in the number of small hammer mills in Nyasaland in recent years and more of the people can now eat whole-meal flour if they wish. In fact, however, in most cases the *madeya* is still separated from the *mphale* in the mortar and it is the *mphale* only which is taken to the mills for making into flour.

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REVIEW

AN INTRODUCTION TO TROPICAL AGRICULTURE, by Sir Harold Tempany and D. H. Grist, published by Longmans, Green and Co., London, 1958, 347 pages, 22 plates, price *40s.*

The main sections of this book deal with the tropical background, agricultural practice in the tropics, and economic considerations. Nineteen chapters are included in these three sections, and the wide field of tropical agriculture is covered extensively rather than intensively, giving a comprehensive introduction to the subject. While this is not intended as a reference book, it gives many facts and figures on tropical aspects of soils and fertilizers, soil conservation, irrigation and drainage, weed control, pests and diseases, grasses and fodder plants, animal husbandry, processing and storage of tropical crops, and cropping sequences. The section on economics deals with marketing and transport, land tenure, and finance and credit. The book will be of great value to those students, agricultural officers, farmers, and administrators who have to adapt their knowledge of temperate agriculture to tropical conditions.

D. W. D.

A REVIEW OF THE BIOLOGICAL CONTROL OF AGRICULTURAL PESTS IN THE SEYCHELLES

By J. F. Guy Lionnet, Department of Agriculture, Seychelles

(*Received for publication on 24th October, 1958*)

Prior to 1936, when D. Vesey-Fitzgerald started his investigation on Seychelles coconut scale insects, work on the biological control of agricultural pests in the Seychelles had only consisted in the introduction of entomogenus fungi, one of which, *Cephalesporium lecanii* has established itself and is common on coccids of cinnamon, citrus and coffee, and is considered responsible for the successful control of the coffee green scale *Coccus viridis* (Green) at higher altitudes in the Seychelles. Fitzgerald's investigation revealed that four species of scale insects, *Ischnaspis longirostris*, Sign., *Pinnaspis buxi*, Bouché, *Chrysomphalus ficus*, Ashm. and *Eucalymnatus tessellatus*, Sign. were especially prevalent on coconut in the Seychelles. As no effective natural enemies of these coccids existed locally, Fitzgerald introduced four species of coccinellid predators from East Africa and one species from India to prey on them. They were: *Chilocorus distigma*, Klug., *Chilocorus wahlbergi*, Muls., *Chilocorus nigritus*, F., *Exochomus ventralis*, Gerst and *Exochomus flavipes* Th. Of these *C. wahlbergi* did not establish itself while *C. nigritus*, the species from India, became and still is the commonest species. Fitzgerald also introduced a sixth coccinellid from Mauritius, *Rodolia cardinalis*, Muls., to prey on *Icerya seychellarum*, Westw., the mealy-bug of fruit trees. Although not as successful as the other species, *Rodolia* has been useful in keeping in check *Icerya*. The consequence of these introductions was the spectacular control, in a matter of months, of the scale insect population of the coconut groves, with as a result a substantial increase in the coconut crop of the islands from the year 1940 onwards.

Thus was the main industry of the Colony saved from a serious threat and thus were the Seychellois made conscious of the pontentiality of biological control. Unfortunately attempts at biological control are far from being always a success, as will appear later in this paper.

With the control of scale insects assured, there remained two important coconut pests in the Seychelles: the rat and the lymexylonid coconut trunk borer *Melittomma insulare*, Fairm. The rat is an old enemy of the coconut and has been more or less kept in check by trapping and poisoning. R. Dupont once estimated the toll taken by rats to be 10 million coconuts per annum, but this is now considered to be exaggerated. Rat infestation is irregular and the damages caused in certain areas where little attention is paid to rats may be great. It is interesting to note here that the premium for rat tails, paid by the Seychelles Government, accounts for some 125,000 rats per annum. On the other hand *Melittomma*, since its discovery in the Seychelles in 1904, has emerged as the most serious local coconut pest. The possibility of a biological control of these two pests was therefore explored by the Department of Agriculture.

In 1949, 1951 and 1952, Cape Barn Owls, *Tito alba*, were introduced from East Africa by F. Durocher-Yvon and J. N. Milsum. Cape Barn Owls, whose diet consists mostly of rodents, were known to feed especially on rats. It was therefore hoped that they would be able to control the local rat population. A first batch of three birds, introduced in 1949, was liberated on Plate Island, an isolated coral island. Informations received in the course of the following months were that they were feeding on rats, which appeared to have decreased in number on the island. For some unknown reasons, however, these birds disappeared from the island later on. Larger batches of owls were liberated at Union Vale and Le Niol, on Mahé island, in 1951 and 1952. Fairly recent informations indicate that these birds have been breeding and that they are spreading: owls have been reported on North, Silhouette and Praslin islands, which are 15, 12 and 21 miles respectively from the main island of Mahé. Pellets collected in Mahé were examined at the Coryndon Museum, Nairobi, and were found to contain a large proportion (80 per cent) of rat bones. This indicates that the local diet of the owls is mostly rats. However, it is not possible to say yet whether the Cape Barn Owl will be a success or not.

In 1952, Dr. F. J. Simmonds, of the Commonwealth Institute of Biological Control, D. Vesey-Fitzgerald, of the International Red Locust Control and E. Brown, of the Commonwealth Institute of Entomology, visited the Seychelles in connexion with *Melittomma*. Dr.

Simmonds was of course interested in the possibility of biological control while Fitzgerald and Brown were to investigate the possibility of other means of control. Dr. Simmonds later visited Mauritius and East Africa among other places, in quest of possible predators or parasites. Brown, who visited North-West Madagascar, the only other place where *M. insulare* is known to exist, confirmed Fitzgerald's finding in 1939, that there is no known parasite or predator of the borer. Enquiries by the Commonwealth Institute of Biological Control on the possibility of using parasites or predators of other insects related to *Melittomma* led to small nitulid beetles, of the genus *Rhizophagus*, which are egg predators of lymexylonids of the genus *Hylecoetus*. As a result H. Hanson, in England, started work on these predators, and several consignments of four *Rhizophagus* species were received in 1955. They were: *Rhizophagus dispar*, Payk., *Rhizophagus ferrugineus*, Payk., *Rhizophagus depressus*, Fab. and *Rhizophagus bipustalatus*, Fab. The most important of the four was *R. dispar*, which was received in large numbers. On arrival, these predators were liberated on Cerf and Mahé islands, as prearranged. It was hoped that they would be able to feed on *Melittomma* eggs and might thus carry out an effective control of the pest. A survey of the areas where they were liberated has failed, however, to reveal their presence. They appear to have been unable to establish themselves under local conditions and may have fallen a prey to ants. As *Rhizophagus* beetles are the only known predators of lymexylonids there is little hope of a biological control of *Melittomma*.

A third coconut pest which has received the attention of the Department of Agriculture with a view to biological control is the coconut rhinoceros beetle *Oryctes monoceros*, Ol. This insect is on the whole of minor importance, except on Praslin and La Digue islands, where it is an obstacle to the replanting of coconuts. The problem is especially acute in Praslin where coconut planters have great difficulty in replanting their coconut groves depleted by *Melittomma*. As scoliid wasps are well-known parasites of *Oryctes* larvae, enquiries by F. Durocher-Yvon led to the introduction from Zanzibar in 1949, 1950 and 1951 of *Scolia ruficornis*, F. The first batch of wasps was kept in a cage in contact with *Oryctes* larvae. The very few wasps that emerged some months later were liberated on North Island, where a wasp population has been building up since then. Due to the very limited success obtained with the first batch of wasps, the other batches received from Zanzibar in 1950 and 1951 were liberated on Mahé and La Digue islands immediately on arrival. These wasps do not appear to have been breeding as none has been recovered. On the other hand, due to the original small population of wasps on North Island, it was only in 1956 that batches could be collected there for liberation in Praslin and La Digue. Since then there have been unconfirmed reports that *Scolia* wasps have been seen on those two islands. There is also an unconfirmed report that *Scolia* wasps introduced on Denis island, from North Island, are breeding there. For the time being it is not possible to say whether *S. ruficornis* will be able to control *Oryctes*, even on North Island where it has established itself. Due to the relatively long life-cycle of the wasp, success, if any, is bound to be slow.

S. ruficornis being an uncertainty, the Department of Agriculture has studied and tried other prospects of biological control of *Oryctes*. Large luminous click-beetles, *Pyrophorus pellucens*, were imported from Trinidad in 1954. It was hoped that the carnivorous larvae of this elaterid would feed on *Oryctes* larvae. Three consignments of *Pyrophorus* were received through the Commonwealth Institute of Biological Control and liberated on Mahé, Praslin and La Digue islands respectively. None has been recovered so far. It is therefore very unlikely that they have been able to adapt themselves to local conditions. The Department of Agriculture is now studying the possibility and advisability of importing another *Oryctes* predator from Zanzibar. It is the assassin bug *Platymerus rhadamanthus*, Gest. Other predators that are receiving consideration are certain beneficial nematodes of the genus *Rhabditis*, that parasite *Oryctes* larvae.

During his visit to the Seychelles, in 1952, Dr. F. J. Simmonds had suggested the trial of *Leionota*, a small tiger-beetle, against the banana weevil *Cosmopolites sordidus* Gr. This suggestion was welcomed by the Department of Agriculture and several consignments of *Leionota quadritentata*, *Leionota columiana* and of another tiger-beetle, *Plaesius javanus*, were received from Trinidad in 1952, 1953 and 1954. When put in the presence of *Cosmopolites* larvae the tiger-beetles attacked and devoured them readily. The beetles, on arrival, were therefore liberated in banana plantations infested with the weevil on Mahé,

Praslin and La Digue islands. Surveys of these plantations have however failed to reveal the presence of the predators. There is therefore little or no hope of their establishment.

In 1955, the Citrus Black Fly, *Aleurocanthus woglumi*, Ashby., was seen in the Seychelles for the first time. Its detection was followed by an intense and rapid infestation of citrus trees in Mahé island, especially in the neighbourhood of Victoria. The Commonwealth Institute of Biological Control, when contacted, advised the importation of the eddy wasp *Eretmocerus serius*, Silv., a parasite of nymphs of *Aleurocanthus*. Several consignments of this aphelinid were received in 1955 and 1956 from Jamaica. Although all the consignments but one arrived in bad condition, due to the long air journey, the tiny yellow wasp had established itself by the end of 1955. Distribution of citrus twigs with leaves bearing parasitized *Aleurocanthus* nymphs was started early in 1956. In this manner the wasp was spread all over Mahé and on certain other granitic islands, with quick and effective establishments. An effective control is now obtained. A heartening feature is the almost automatic *Eretmocerus* re-appearance, and therefore parasitization of *Aleurocanthus*, wherever the aleurodid re-infests citrus trees. Since Fitzgerald's introduction of coccinellid beetles, *Eretmocerus* is the only other introduction to have been a real success so far.

Another pest against which a trial in biological control has been effected recently is the giant *Achatina* snail. The predacious carnivorous snail, *Gonaxis quadrilateris* Preston, which preys on the giant snail, was introduced from Kenya last year and liberated on Mahé and Cerf islands. In the course of a survey on the latter island, this year, a number of young *Gonaxis* were recovered. There is therefore an indication that *Gonaxis* has been breeding and there is the hope that it may eventually control the giant snail. Efforts are being made to obtain more *Gonaxis* snails from Kenya.

Other pests that are being studied from the point of biological control include the coffee green scale *Coccus viridis* (Green), the long-tailed mealy-bug, *Pseudococcus adonidum* (L.), which was not known to exist in the Seychelles and which has recently been recorded on coconut on Poivre and Darros islands, and the scale *Lopholeucaspis cockerelli* (De Charm.), which was also unknown in the Seychelles and which has now been recorded on coconut on Alphonse island.

It has been said above that attempts at biological control of insect and other pests are far from being always a success. This is illustrated by the following figures: out of 11 agricultural pests against which biological control has been tried in the Seychelles, six are effectively controlled, the fate of three is uncertain and two appear to have been unaffected, while out of 18 introduced predators and parasites only nine have been successfully established.

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A STUDY OF A SMALL BASKET-TRAP RIVER FISHERY IN KENYA

By Vernon D. van Someren, Ministry of Forest Development, Game and Fisheries, Kenya

(*Received for publication on 10th December, 1958*)

Basket traps are one of the oldest forms of fishing apparatus known, and their use is world-wide among primitive peoples for the capture of both marine and freshwater fish. In Kenya various types are extensively used by the fishing tribes such as the Jaluo, Giriama and coastal Arabs; and even in European countries lobster pots and pike and perch traps are merely modern utilizations of the same idea.

In Africa the baskets, made of sticks, withies or plaited strands may be round as in inland waters, or flat-bottomed as on the sea-coast. Their design and structure may be simple or complex, but they always employ the same principle of a non-return funnel through which the fish enter the trap.

They may be immersed in water singly, facing up-stream or down-stream, and used with or without bait; or they may be incorporated in small barrier fences which lead the fish into the trap in narrow portions of rivers, or placed in very large serial rows fixed in a barrier right across the river, as in the Jaluo *kek* (Whitehead, 1958*a*).

Those incorporated in barrier fences in series, with entrances directed up or down-stream, are usually employed unbaited to catch migrating fish. Their efficiency is high in the appropriate season, provided the fence withstands the floods during which the fish migrate. Basket traps fished singly, baited or unbaited are, in rivers at least, relatively inefficient when exploiting more static populations of fish (Whitehead, 1958*a*).

Intensive African fisheries, based on the use of single traps or barrier traps, have been studied by Whitehead (1958 *b, c*,) on the Sabaki River and the rivers of Nyanza Province in Kenya.

Since 1951 African staff employed at the Fish Culture Farm and Inland Research Station of this Ministry have fished with single basket traps in the portions of the Ragati and Sagana rivers adjacent to the Research Station, where the Ragati joins the Sagana (37° 14′ E, 0° 40′ S). All fish caught have been examined for species, length, weight, sex and maturity state, and scales, operculars and otoliths collected. Unfortunately the data collected between 1951 and 1953 were lost by theft during the Emergency, the Station being closed for security reasons in 1953.

In 1955-56, when work was resumed there, African staff were again instructed to fish, but in the absence of trained staff at that time the data collected have proved unreliable, and the 1956 records are incomplete. In March, 1957, a trained Jaluo assistant again commenced fishing this Ragati-Sagana junction area with basket traps, and his data form the basis of this paper. Prior to our own operations in 1951, this area had also been fished privately by a local self-employed Jaluo for some two years who sold all the fish he caught. Apart therefore from a short period of a few months in 1954 and 1956, this area was not a virgin fishery, but had been exploited sporadically for several years.

Methods

Such simple basket trap fisheries are very dependent on river conditions, the traps being unfishable in times of heavy flood. In fact the 1957 fishery was carried on for seven months only before November floods carried all the traps away, and the effort was not resumed.

In addition to the traditional stick traps made locally, half-inch-mesh wire traps with a single non-return funnel were also used. There was no difference in their efficiency, and the life of each was equally short—about two months or so before the material rotted and the trap had to be mended or re-made. A few of the traps were also damaged from time to time by small crocodiles trying to reach the trapped fish.

The activities of this Jaluo assistant could not be supervised intensively, with the result that this small fishery was conducted in a somewhat typical haphazard fashion, with varying effort and attention to detail. His instructions were merely to catch sufficient fish for study, and not to conduct a commercial fishery; and it was left to him to decide when and where to place his traps and examine the catches within the area of study, as long as changes were noted.

The baskets used were approximately three feet in diameter at the entrance end, tapering

to a few inches at the closed end, and about four feet long, being fitted with an 18-inch non-return funnel at the wide end. This funnel had an internal opening of about four by three inches, and the space between withies of the basket frame was about half an inch at the widest.

The baskets were fished singly, usually baited with a ball of cooked maize flour, and sunk in about three to four feet of water at the edges of the rivers with the entrances directed down-stream. Trials with unbaited traps, or traps facing up-stream, were not successful. The traps were emptied in the mornings, and though they were left in the water all day and night very few fish appeared to enter during the day.

When low river conditions permitted, the baskets were incorporated in a small *mugono*, or fence of sticks placed vertically across a small side channel in the river, up to six feet wide, with the entrances facing down-stream. This was usually the most successful method. Within the half-mile of each river available there were only three or four places where a trap could be fished easily. In low-water conditions it was evident that a single small suitable pool could be readily fished out in perhaps a week; hence the traps were fairly constantly changed from river to river and place to place in the same river in order to keep up the supply of fish.

In spite of a low fall on the Ragati 400 yards up-stream of its confluence, and similar falls on the Sagana, the fish fauna available to these traps is identical in both rivers. Because of this and the varying effort as regards number of traps in use, time and place of setting, the data have been treated as a whole for this one area, and no distinction has been made between results from different places in each river.

As in previous studies all fish were examined in the laboratory the same day as caught, notes being taken of species, length, weight, sex and maturity state as before, together with scales, operculars and otoliths.

Daily water samples from each river were examined for electrical conductivity (Dionic Water Tester), turbidity (Eel Absorptiometer), and occasionally pH (Indicator solutions). Daily maximum and minimum water temperatures were recorded for the Ragati river, but the records are incomplete, insufficient care having been taken to secure the thermometers against flood and theft. Similarly the records for conductivity and turbidity are not available for the whole period since the necessary apparatus was not available until after fishing had commenced.

Ragati river heights recorded are those for the River Gauge 4BB1, situated about one mile above the Research Station, and made available through the courtesy of the Hydraulic Branch of the Ministry of Works. This is an uncalibrated gauge, hence cusec discharge figures are not available. This gauge is read only two to four times a week in the mornings, and figures have been averaged for the periods under study. There is no gauge available at a corresponding position on the Sagana River.

The River Environments

The portions of the rivers studied lie at an altitude of 3,940 feet in the Central Province of Kenya.

The Ragati River arises on the lower forested slopes of Mount Kenya, and is tributary to the Sagana at Sagana Station. In the confluence area it is fairly fast-flowing, about 10 to 15 feet wide, and varies in depth from one foot to several feet in the deep pools.

The Sagana is formed by the confluence of three main tributaries, 10 to 15 miles higher than Sagana Station; the Sagana proper (from Mount Kenya), and the Chania and Gura (from the Aberdares), all of which arise from the moorland level above 11,000 feet. Other smaller rivers become tributary during its course. At Sagana Station the Sagana is relatively mature, with a width of 30 to 40 yards, an average depth of several feet, and is fairly slow flowing. Below the Ragati junction it becomes the Tana River, the main river draining the north-eastern slopes of the Central Highlands to the Indian Ocean.

The regime of the Ragati River in 1957 is illustrated in Figure 1. 1957 was a year of early and heavy rainfall on the river watersheds from March to June, and the averaged daily river heights for six-day periods show a typical curve rising to 4.5 feet at the end of May, then falling slowly during the subsequent dry season up to October. Thereafter the short rains of November-December caused a further flooding to a lesser height than the long rains. As is typical of most east-flowing rivers in Kenya discharge is minimal in the short dry season of January-February.

The electrical conductivity (expressed as reciprocal megohms) shows the usual inverse

correlation with river height already described by van Someren (1952 *a, b*), the flood waters diluting the concentration of soluble electrolytes.

Turbidity (expressed as percentage transmission of light, not as percentage turbidity) shows a rise at the beginning of the main floods and at each subsequent small flood in the dry season in a very precise fashion (e.g. periods ending 17/9, 21/10, 3/11, 9/12), but at the height of the floods, and when the river remains high, the water becomes clearer. Only the first rises of water cause heavy muddying as bank debris and soil are washed away, thereafter there is less erosion except after an intervening dry spell.

The few temperature records suggest little variation, the water being slightly colder in floods and warmer in low water, and they fluctuate between 65 to 70° F (18 to 21° C) at this altitude.

The physical and chemical characteristics of the Sagana River from 5,600 feet upwards over a period of years have already been described by van Someren (1950, 1951, 1952 *a, b*). At this lower altitude, where the river is more mature, the conductivity, and hence concentration of soluble electrolytes, is higher (as would be expected with the additional drainage area above) being about twice as great in both low and high water. The river is also a good deal more turbid because of the greater drainage area involved. This also holds for comparison with the Ragati at the same altitude and is in fact an expression of the greater maturity of the Sagana compared with the Ragati at Sagana Station.

Though river level readings are not available for the Sagana, the fluctuations in conductivity, although of greater magnitude, are similar in their sequence to those of the Ragati. This suggests that the flood regime of the Sagana in 1957 was very similar to that graphed for the Ragati, with peak floods in the long rains perhaps a few weeks earlier. To avoid confusion in the figure, the light transmission figures for Sagana water are not graphed in Figure 1, but they average somewhat less than for the Ragati; the river is usually more turbid. The pH varies very little between 6.8 and 7.2 in both rivers.

Fish Fauna

Only three genera of fish are available to such a basket trap fishery in these portions of the rivers. Of the eels *Anguilla nebulosa labiata* Peters is the dominant species, with *A. mossambica* Peters very rare. Of the cyprinid fish two genera occur, *Barbus* and *Labeo*. Of two kinds of the former *B. tanensis* Gunther predominates; the other, a "rubber-lipped" form, is not yet satisfactorily identified, and is only rarely caught. A single species of *Labeo* enters the fishery, *L. cylindricus* Peters.

In this area there also occur a number of smaller species of *Barbus* and siluroids, and a cichlid *Tilapia nigra* Blgr. The Tilapia is rare, and the others are too small in size to be affected by such a fishery. Only very occasional specimens of each were taken in the traps, and they are not considered further here.

The Fishery

The results from seven months trapping are shown diagrammatically in Figure 1. A total catch of 476 fish, weighing 318 lb. 4 oz. was obtained. Owing to the variables involved, effort and catch have been graphed in roughly six-day periods, rather than in set calendar weeks. The data do not permit of a more exact analysis, for the notes are often incomplete; but even with this arbitrary grouping the trends are obvious.

Fishing was started in the period ending 23rd March, suspended for two weeks at the height of the floods (16th May, to 28th May), and again for a few days from 20th June, to 30th June, for trap repairs. Floods in the period ending 3rd November carried all the traps away or broke them up, and fishing ceased. The effort varied from one to five traps per day in various places, depending on their state of repair and enthusiasm for making new ones, but in general tended to rise as the river level fell in the dry season.

Interpretation of the catch rate figures is not easy. In some ways the graph resembles classical examples of fishery exploitation, with initial high yields falling to a lower, more steady, level which does not increase markedly in spite of increased effort. This may indeed be so, for as explained above, places available for placing traps effectively were few and may be readily fished out if the population is static. But there may be another explanation for the initial high yields in that these were obtained at the beginning of a flood period when, as Whitehead has shown (1958*c*), migratory fish such as *Barbus and Labeo* become very active and move about a good deal. The slight rise in

catch rate at the beginning of the October floods tends to support this, but it may be equally significant that higher catches were made after each period of rest, a fished-out area being replenished from elsewhere in the river. Such a trend is well known in fishery dynamics, but over a long-term rest this replenishment is due to actual increase of the population by recruitment of young, which cannot apply over a short-term period such as this.

Since cause and effect cannot really be determined over such short-term periods it would be necessary to follow the fluctuations of catch over several flood seasons successively, and maintain a steadier effort, before the full significance of such trends can be determined. Furthermore, the influence of a single baited trap is probably very local, and availability of migratory fish varies a good deal throughout the year. There are no statistics yet available for the populations of these middle-river fish. Nor is there any precise correlation between effort and catch in this short-term fishery; in fact some of the highest catches were made with an effort of only one trap per day, and the lowest with three or more traps in action.

In general, except where large eels provide an unexpected "windfall" and increase the catch weight greatly (as in period ending 4th May) the weight per trap per day follows very closely the number of fish per trap per day. From the point of view of profit the results show the inefficiency of such basket-trapping on a small scale in a river. Even at an average price of Sh. 1 per lb., a catch averaging just over one fish per day of an average weight of 12 oz. is clearly not very profitable. A fisherman operating on these lines for private gain would however show a good deal more care in trap-setting and emptying than did our assistants, and the Jaluo fisherman operating in this area prior to 1952 appeared to be making about Sh. 100 per month. He was, however, exploiting a virgin fishery, and worked hard at it with a good many traps; unfortunately he was suspicious of giving information readily, so these figures are only tentative.

Nevertheless this cash profit aspect of such small fisheries must not be over-emphasized. It is as important to realize that for negligible capital outlay, and a time expenditure of only an hour or so a day, an operator of two or three such baskets in these easterly flowing rivers can supply his family and himself with a regular supply of at least half-a-pound of first-class protein daily. Such animal protein might otherwise cost him a very great deal more to buy in the same period of time, and in areas where protein malnutrition is prevalent such as this, the benefit to health of such readily obtainable supplies as fish cannot be measured in terms of money.

From our studies of river fisheries elsewhere on the Sabaki and Nyanza rivers, Whitehead (*loc. cit*) has shown that fixed engines such as large barriers traps, and smaller barriers across flood pools, both of which depend for their catches on seasonal movements of whole fish populations and not attraction, can be most profitable, with catch rates running into hundreds of pounds per trap per day; indeed they can be totally destructive of whole segments of fish stocks at a particular time. There is no doubt that, as with sport fisheries on a river, individual "baiting" methods are inefficient and take only a small fraction of the available fish. Large and profitable catches can be made only by exploiting the seasonal movements of fish up and down a river, when their susceptibility to properly designed trapping methods is greatest. This aspect is now studied by a fixed weir trap of novel design on the Ragati River, and the results will form an interesting comparison to the present study.

Composition of the Catches

Whatever may be the true significance of the total trends shown in Figure 1, there is no doubt from Table I and Figure 2 that even in the short period of seven months the composition of the catch altered greatly. Although seasonal trends in altering fish stocks cannot be entirely discounted there is reason to believe that this alteration resulted from the fishery itself exploiting fish of two differing habits and biology in the same area, namely *Barbus* and *Labeo*.

Table I—Percentage Composition of Catches by Months—Ragati-Sagana, 1957

Month	Eels		Barbus		Labeo		Total No. All fish
	No.	%	No.	%	No.	%	
April ..	6	9·5	6	9·5	51	81·0	63
May ..	4	19·1	7	33·4	10	47·5	21
June ..	5	9·6	20	38·6	27	52·0	52
July ..	1	0·9	73	67·5	34	31·5	108
August	2	4·1	34	62·5	13	26·5	49
Sept. ..	0	0·0	29	70·5	12	29·5	41
Oct. ..	0	0·0	32	71·0	13	29·0	45

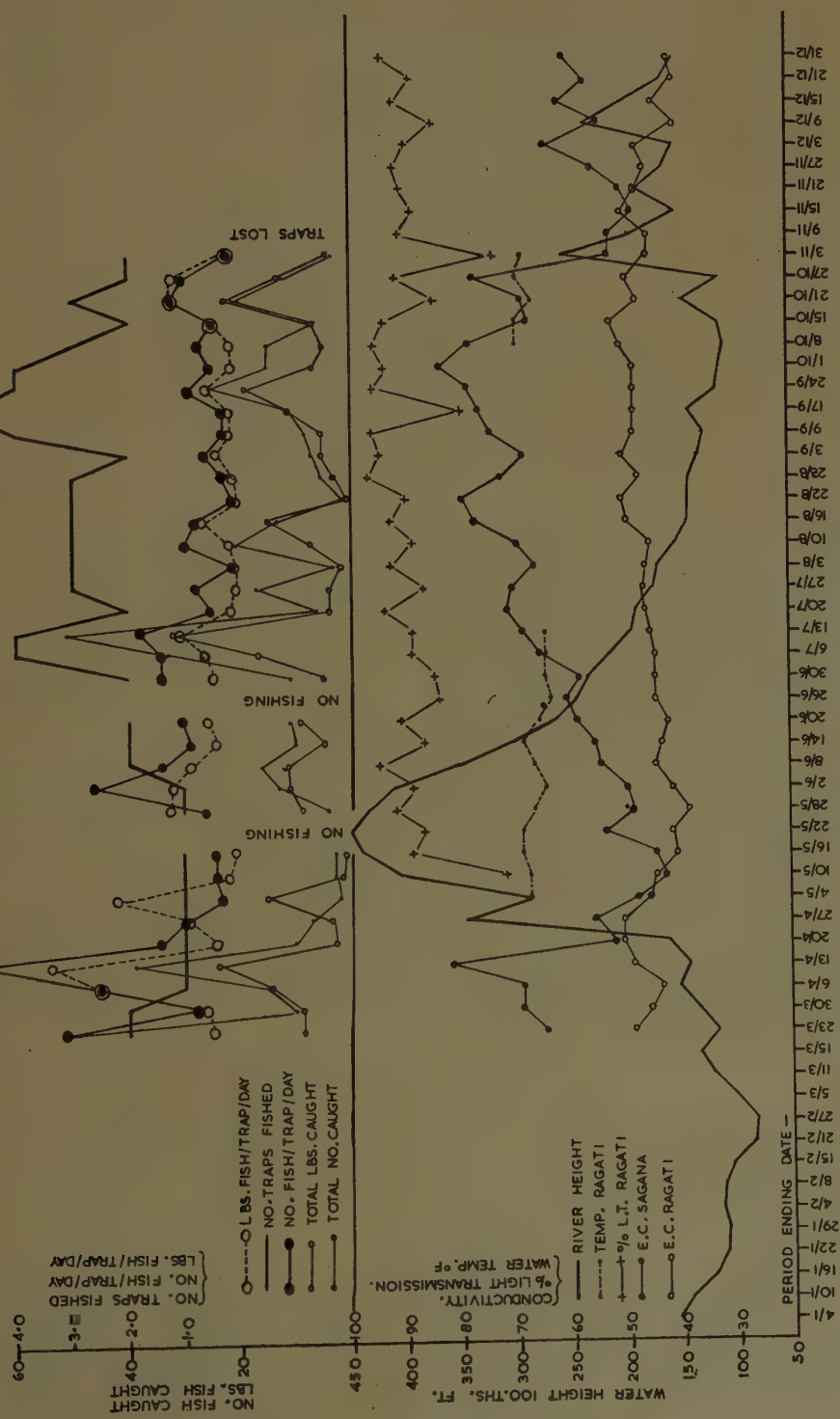

Fig. 1.—River and catch data, 1957

Before considering this, however, it is evident that eels, which are the heaviest and most readily saleable fish in the rivers, form only a small fraction of the total catches from such a fishery. They are known to be abundant in these portions of the rivers, but a basket-trap fishery of this type does not exploit them as their abundance would warrant. They are not available to such methods, probably because of their habits, and are caught only occasionally as they enter a basket to prey on fish already trapped, although a few stomachs did contain bait only.

It is also clear that they are more frequently caught in the flood months. They probably move readily as the water rises, and it is suspected that maturing eels at least move down the rivers in these months on their spawning migration to the sea, though, as with Frost's findings in Kenya (1955), none of the eels caught were either "silvering" or markedly mature. It is probable that trapping of migrating eels, as in temperate zones, would be a much more profitable method of capturing these desirable fish, and information on this should shortly be available from the new weir trap, designed especially for this purpose.

With regard to *Barbus* and *Labeo*, although total catches of each were roughly similar, Figure 2 shows how the catches gradually altered from a *Labeo* dominance to a *Barbus* dominance, and it is evident from Table II that the two fish are being exploited at two distinctive phases of their respective biology. *Barbus*, both male and female, mature at a much geater size and weight than do *Labeo* (Figures 3 and 4), and apart from the October catches such mature *Barbus* do not enter the fishery to any great extent. This may be due to differences in habits as they mature, or may be purely mechanical in that a mature *Barbus* of 30 to 35 cms. length is a deep-bodied fish and cannot enter a trap of the type used with any ease. *Labeo* of this size are more slender. By far the greatest proportion of *Barbus* trapped were immature fish of 15 to 24.9 cms. (Table II). By contrast, throughout the same period, *Labeo* entered the traps at all stages of maturity, with a marked preponderance of ripe or spent fish in the early flood months.

Table II shows an interesting comparison; while the bulk of *Barbus* entered the traps in length groups 15 to 24.9 cms. as immature fish, the majority of *Labeo* entered the traps in length groups 25 to 29.9 cms. and longer, often as mature fish. While the habits of juveniles of both kinds may be different, there is no reason to suppose that this is so, or that it would account for the differences observed. Certainly no *Labeo* in the 10 to 14.9 cms. group were caught, by contrast with several *Barbus* of this size group, and they may in fact be too slender to be retained by the mesh used. But the difference in catches in the 15 to 19.9 cms. group of both, for example, which is a size readily held in the traps, is most marked.

Observations at Sagana on fish migrating up the falls in flood have shown that *Labeo* migrate in great numbers up-stream as readily as do *Barbus*, and yet these maturing fish enter traps in greater relative proportion all the year than do *Barbus* of similar size groups. Though figures are not now available, the original trapping data from 1951-52 and 1955-56 suggested that *Labeo* were in fact the more abundant fish of the two when trapping started after a period of rest, and it seems probable that exploitation by such basket traps will tend to reduce the *Labeo* population first. Whether this is due to differing habits, or

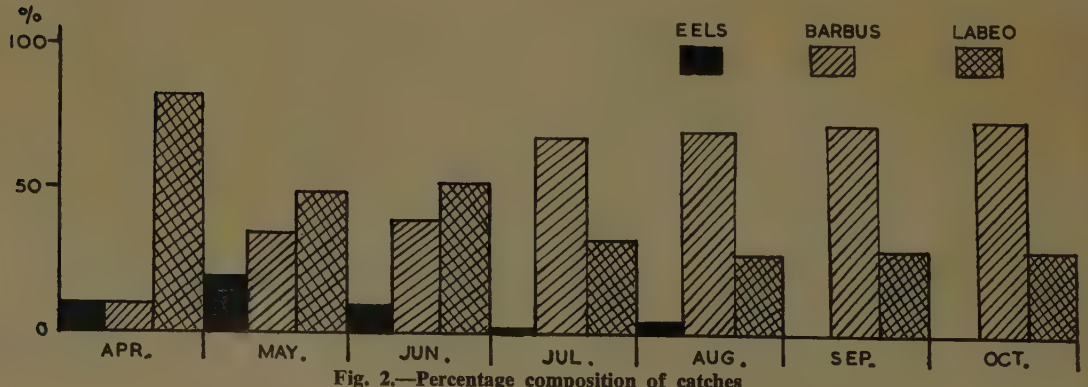

Fig. 2.—Percentage composition of catches

TABLE II—LENGTH FREQUENCY DISTRIBUTION OF CATCHES BY MONTHS—RAGATI–SAGANA, 1957

(The figures given are percentages in each length class; the number of fish per month are shown in Table I)

	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER	
	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo
LENGTH CLASS (CMS.)														
10–14·9 ..	50·0	—	—	—	—	—	4·1	—	2·9	—	3·7	—	—	—
15–19·9 ..	50·0	15·6	43·0	10·0	35·0	14·8	44·0	8·8	38·3	—	33·3	16·7	11·7	—
20–24·9 ..	—	35·3	43·0	20·0	35·0	29·8	34·2	20·6	47·0	15·4	25·0	25·0	5·9	15·4
25–29·9 ..	—	29·4	14·0	50·0	25·0	33·3	12·3	50·0	5·9	23·2	33·3	16·7	32·4	46·2
30–34·9 ..	—	13·7	—	10·0	—	22·2	2·7	20·6	5·9	46·2	—	41·8	29·4	38·4
35–39·9 ..	—	5·9	—	10·0	5·0	—	—	—	—	7·7	3·7	—	11·7	—
40–44·9 ..	—	—	—	—	—	—	—	—	—	7·7	—	—	8·8	—

because such traps undoubtedly catch more mature *Labeo* than mature *Barbus* and thus diminish the immediate spawning potential of *Labeo* in the area, is a matter for speculation.

The extent of longitudinal migration of each is not known. If *Labeo* do not move as far up-stream as *Barbus*, and they are generally more sedentary fish, the second explanation may be more likely. Work is now being carried out on these lines by marking experiments in this area, and observations so far have shown that *Labeo* spawning is widespread in the immediate vicinity of the fishery whereas *Barbus* breeding is not. Their spawning habits are different; *Labeo* spawn in flooded grass areas and side swamps off the main channel while *Barbus* apparently spawn on stony river bottoms.

The results are at least suggestive that a single fishing method may perhaps alter the whole local composition of fish stocks to the detriment of one species, a fact known of course from other types of fisheries. In this instance, it is probable that little harm would result, since both species have an equal commercial value in this area.

SEX RATIOS AND MATURITY

The very few eels caught do not permit of any detailed analysis of their biology. In general they conformed completely with all features already described by Frost (*loc cit.*). Varying in length from 47.0 cms. to 116 cms., and 6 oz. (170 gms.) to 7¼ lb. (3.5. Kg.) in weight, all the *A. nebulosa labiata* were immature females. Males do not occur as far up these rivers in any numbers (Frost, *loc. cit.*). The one *A. mossambica* caught, of 75 cms. and 3 lb. (1.4 Kg.) in weight was also an immature female. As noted by Frost, this is a rare species in Kenya, at the limit of its range northwards, being the common eel in South Africa.

With *Barbus* and *Labeo* it will be noted that only three gonad states were recorded—immature, ripening or ripe, and spent. These stages are relatively easy to distinguish in these fish, and in the absence of supervision, closer analysis was not possible.

It is not easy to sex small immature *Barbus*: those that could be sexed showed in general a very even sex ratio throughout the period (Table III). Most *Barbus* caught were immature, and only a very few ripe or spent fish were caught in either the first or second flood periods.

Very small *Labeo* are also difficult to sex; with those confirmed, apart from a slight preponderance of males in the flood months of May, there is a greater proportion of females in the catches in all other months (Table III), about one-fifth more females than males. Whether this uneven ratio is natural or trap-induced is not known, but increased fishing pressure on the female part of a stock may also assist in the total diminution of *Labeo* stocks noted above, since it is likely that one male may fertilize several females.

TABLE III—SEX RATIO AND MATURITY STATE BY MONTHS—RAGATI-SAGANA, 1957 (EXCLUDING UNSEXED FISH)

	APRIL		MAY		JUNE		JULY		AUGUST		SEPTEMBER		OCTOBER	
	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo	Barbus	Labeo
Total ♂ ..	1	20	4	6	8	9	30	11	12	5	16	5	10	3
Total ♀ ..	1	22	2	3	8	18	29	21	19	8	11	7	22	10
% ♂ ..	50·0	47·5	66·6	66·6	50·0	33·3	51·0	33·3	39·0	38·5	59·5	41·6	31·2	30·0
% ♀ ..	50·0	52·5	33·3	33·3	50·0	66·6	49·0	66·6	61·0	61·5	40·5	58·4	68·8	60·0
immature	100·0	60·0	75·0	16·6	100·0	33·3	93·5	63·5	100·0	80·0	94·0	75·0	60·0	33·3
♂														
% ripe, ripening	—	40·0	25·0	83·4	—	11·1	—	—	—	—	60·0	25·0	30·0	66·6
% spent	—	—	—	—	—	55·6	6·5	36·5	—	20·0	—	—	10·0	—
♀														
immature	100·0	82·0	100·0	—	87·5	83·5	96·5	81·0	100·0	75·0	100·0	71·5	68·5	60·0
% ripe, ripening	—	13·7	—	—	12·5	—	—	4·8	—	12·5	—	—	9·1	40·0
% spent	—	4·3	—	100·0	—	16·5	3·5	14·2	—	12·5	—	28·5	22·4	—

While immature *Labeo* again preponderate in catches in all months as with *Barbus*, the catches also include a higher proportion of sexually active fish of both sexes (*Labeo*) in all months. It has been noted that spawning appears to be completed within the first few days of each flood period, hence it seems that the fish may remain almost ripe or ripening for some months, or in a spent-recovering stage also for a long period. Since so few mature *Barbus* entered the traps, it is not known whether they correspond to *Labeo* in this respect, though they also spawn only in the flood season. These larger *Barbus* are now being exploited by four-inch gill-nets in the Sagana, and most of the large fish caught thus in December, 1957, and January, 1958, have been sexually active (Figure 3), but data throughout the seasons are not yet available.

Lengths and weights at maturity are indicated in Figures 3 and 4, in both kinds males mature at a smaller size than females. For *Labeo* males, first maturity is at 23 cms., and *Barbus* males at 31 cms.; female *Labeo* mature at 29 cms., female *Barbus* at 36 cms. In both however, earlier or later maturing fish occur in both sexes, and these figures are general averages.

The length/weight curves shown in Figures 3 and 4 have been fitted by eye, but are typically exponential as for other fish. The mathematical relationship and relation to condition will be dealt with elsewhere. What these curves represent in terms of age and growth rate is not yet known, since methods of estimation are still being worked out; both scales and operculars show clear annuli, but their significance is not determined yet.

The data do not indicate any major difference between male and female fish as regards growth in either genus, but do indicate the general range of such fish entering this type of fishery.

FOOD

In these rivers, both *Barbus* and *Labeo* are herbivorous grazers. The stomach contents of these trapped fish usually consisted of the maize meal used as bait. In the few which contained natural food, the stomach and intestines contained an unrecognizable "mush" of algal remains, with a good deal more mud in the *Labeo* stomachs than in the *Barbus*. In aquaria *Labeo* have been observed to be more unselective feeders than *Barbus*. Rectal smears from *Labeo* show that all forms of algae are apparently digested, unlike cichlid algal feeders such as *Tilapia esculenta* and *T. nigra* which utilize only the diatoms ingested

Eels are largely carnivorous. Frost (*loc. cit.*) found mainly fresh-water crabs in the eels she examined from the upper reaches of the same two rivers. From the 18 *A. nebulosa labiata* trapped during this study in these lower reaches, seven stomachs were empty. Of those with food, eight contained bait (maize meal); four contained fish remains of *Barbus* and *Labeo* possibly eaten in the trap; two contained grasshoppers, and one contained a beetle.

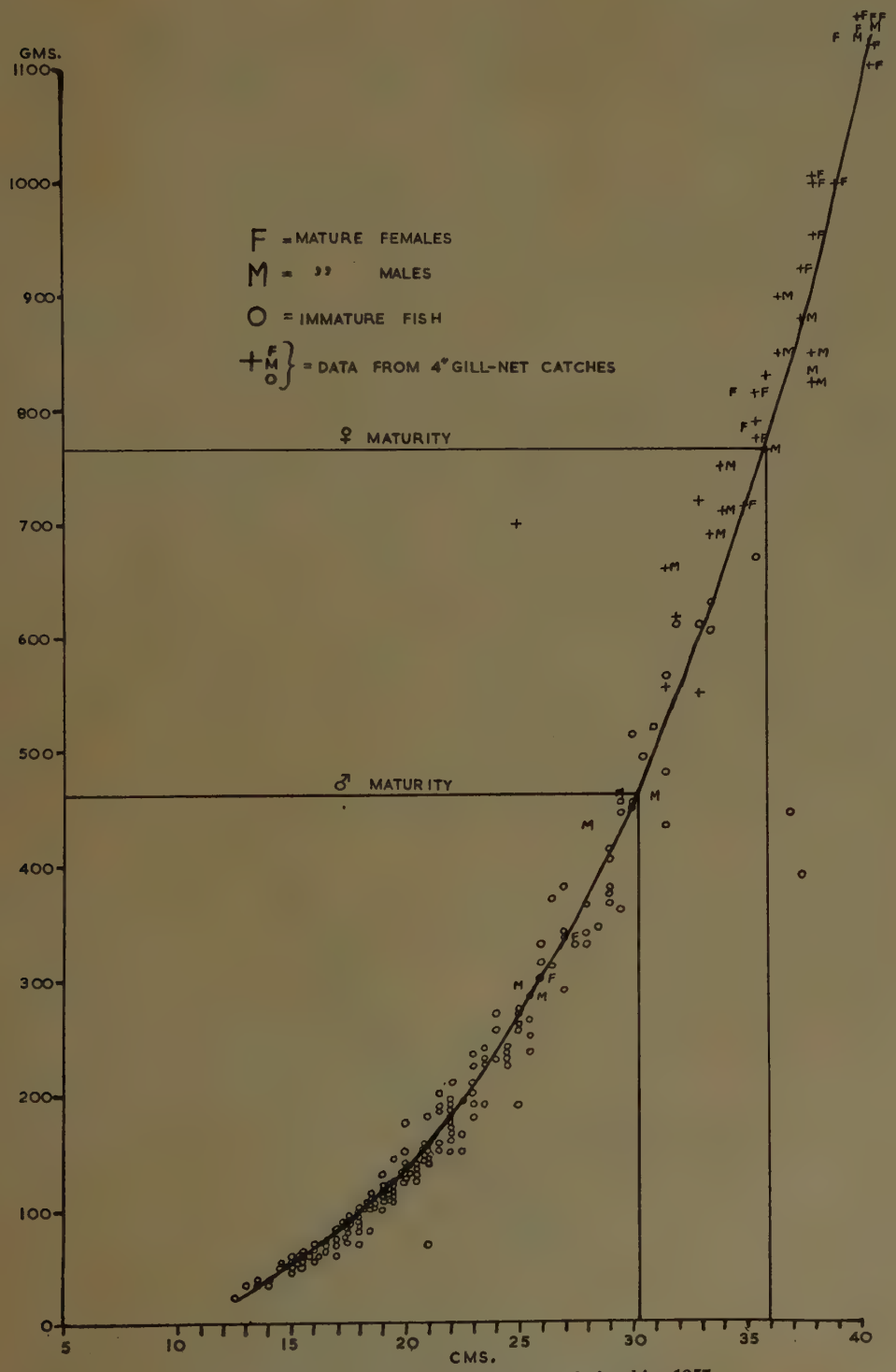

Fig. 3.—*Barbus tanensis.* **Length/weight relationship, 1957**

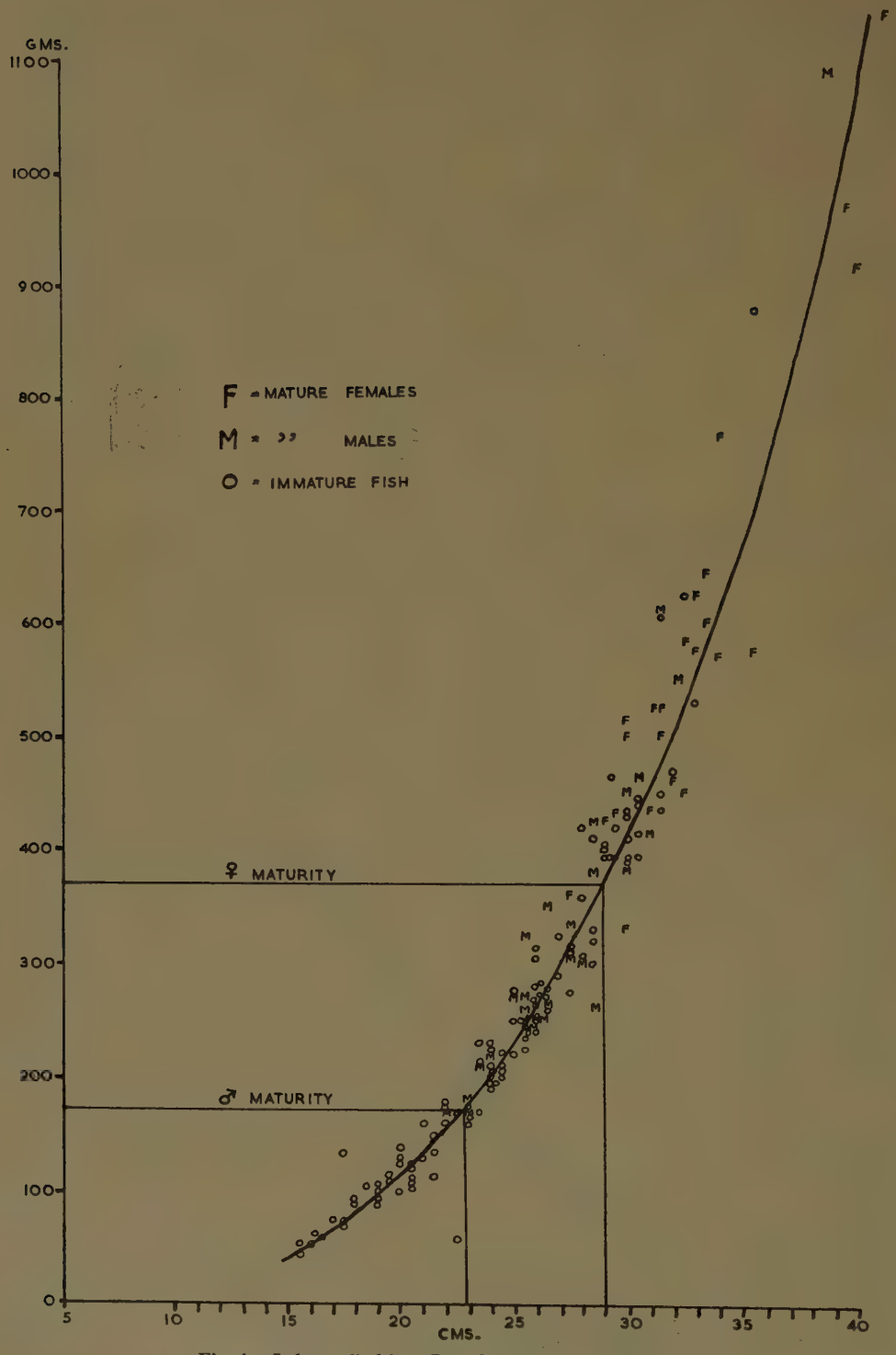

Fig. 4.—*Labeo cylindricus.* **Length/weight relationship, 1957**

SUMMARY

An analysis is given of seven months' operation in 1957 of a small basket-trap fishery in the Ragati-Sagana river junction area, at an altitude of 3,940 feet in Kenya.

The hydrological régime of the two rivers during this period is described, both rivers showing the twice yearly flood periods typical of most eastward flowing rivers in Kenya, with which are associated changes in conductivity and turbidity.

Only three genera of fish enter such a fishery, two species of *Anguilla*, and one each of *Barbus* and *Labeo*. Though total catch showed a diminution in this period in spite of increased effort, this does not necessarily indicate a diminution of total stock available, since all these fish are migratory. Although the effect of fishing on total fish stocks is thus not clear over such a short period, the fishery appeared to alter the composition of the local fish stocks, *Labeo* dominance in early catches being replaced later by a *Barbus* dominance. It is suggested that this change may be due to differences in the biology of the two genera, and data available from the trap catches concerning migration, food, sex ratio, maturity state and length/weight relationship are discussed. Studies on age and growth of these fish are not yet complete.

The results have shown that such a small basket-trap fishery is relatively inefficient from a cash profit aspect, but it can nevertheless contribute materially on an individual subsistence basis to alleviating protein malnutrition, since the supply, though small, is fairly regularly obtainable at negligible cost in such rivers.

ACKNOWLEDGMENTS

My thanks are due to Mr. Michael Opata Ojoo who operated this fishery and kept all the records on which this paper is based. I am also indebted to Mr. P. J. P. Whitehead for much helpful discussion of the results.

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RELEASE OF NEW CEREAL VARIETIES—1959

By H. C. Thorpe and G. E. Dixon, Plant Breeding Station, Njoro, Kenya

(*Received for publication on 12th February, 1959*)

The following new wheats are released by the Department of Agriculture for the 1959/60 season. It will be noted that it is now the policy to issue wheats under varietal names rather than selection numbers which have been used in the past.

Crosses 384 and 385

Seven selections; developed at Molo from the crosses Equator × 318.AJ.4.A.1 and Equator × Kenya Ploughman (i.e. 318.0.3.B.2) respectively. They are suited to the higher altitudes, above 7,500 ft. All are mid-season to late in maturity, of poor baking quality, and of fair to good straw strength. During multiplication they have shown a capacity for high yield, and in stem rust tests show a good general level of resistance to most current races. A special point to be made is that so many rival selections would not normally be released together, but in this case there are excellent crops of all of them and, rather than delay pending a further year's trial, it has been decided to release all immediately.

Below is appended a summary showing the numbers and names of the selections, together with their individual characteristics.

Name	Selection	Ear Type and Chaff Colour	Maturity	Grain Colour	Areas Recommended and Other Notes
Kenya Curlew ..	384.C.7.A.2	B'less, Red	M–S	White	Ol Joro Orok and Kinangop.
Kenya Eagle	384.E.3.E.1	Tip–Bd, Red	M–S	White	Molo and Mau Narok only.
Kenya Hawk	384.E.3.H.1	B'less, Red	M–S	White	Mau Narok only.
Kenya Buzzard ..	384.BU.22.M.1	B'less, White	M–S	White	All areas; but may shed slightly.
Kenya Dove	385.D.4.C.1	B'less, Red	M–S	White	Mau Narok and Kinangop but not Ol Joro Orok.
Kenya Plover ..	385.P.6.A.3	B'less, Red	M–S	Red	Molo and Ol Joro Orok, but not Kinangop.
Kenya Quail	385.Q.3.C.1	B'less, White	Late	Red	All areas.

(1) All varieties should be available as certified pedigree seed.

(2) M–S = Mid-season.

THE CONFORMATION AND CHARACTERISTICS OF A THREE-QUARTER ANKOLE/ABERDEEN ANGUS CROSSED BULL BRED AT WHIPSNADE

By R. N. T-W-Fiennes, Zoological Society of London

(*Received for publication on 12th December, 1958*)

Shortly after the war, some fine Ankole cattle were received at Whipsnade, including a good bull, typical of the breed. The young bull which is the subject of this memoir is a grandson of the original bull and an Aberdeen Angus cow, the progeny being again crossed with Ankole.

It will be necessary to give some description of the Ankole breed and for this purpose I am quoting extensively from Mackintosh (1938), former Director of Veterinary Services, Uganda, for many years Veterinary Officer, Ankole:—

"Among white people, Bahima cattle are known as the Ankole Longhorn. This type of cattle, with their long horns, straight backs, and predominantly reddish brown colour, are clearly distinguishable from the smaller hump-backed, lighter coloured, zebu type which are the cattle of the Eastern and Northern Provinces of Uganda and of Kenya. The average weight of a dressed Longhorn carcass is 450 lb., while that of a West Nile Zebu is 300 lb. In Karamoja (another district of Uganda), however, the zebu type carcass goes as high as 550 lb. The quality of Ankole beef does not come up to European standards either in fat, flavour or tenderness.

The following are the qualities which the Bahima (the Ankole tribe) seek in breeding their stock, in order of their importance:—

1. Colour, *bihogo*, dark red is the choicest colour. Next in order comes *bugondo*, dark red with very small white spots. Third in order of choice comes *mayenzhe*, dark red with larger white spots. This selection agrees with the general valuation of colour amongst the Bahima. Dark red is the true cattle colour in their estimation, and white, *enjeru*, is the colour representing good luck and purity. . . .

2. Next in importance to colour comes the size and shape of the horns, *amahembe*. The most highly prized horns are white and long, forming an oval, with the tips bent forward. Second best are the horns with their tips bending backwards. Horns forming an oval only are not highly esteemed.

3. In general, the *omuhima* desires a large animal with well-formed long legs. The face should be short and broad and the eyes large. A short tail is desired. The hump is not important in the case of a cow but is desirable in the bull.

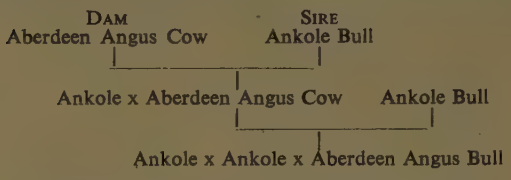
4. In bulls, the penis should be short, for it is supposed to breed better milkers, and small testicles are thought to be conducive to the breeding of heifer calves. . . .

5. Fatness is not considered important. Rich people breed cattle for their appearance, while poor people breed with an eye upon milking qualities as well. . . ."

The Bahima give their cattle names, which are descriptive of their colour, their behaviour or the shape of their horns. Mackintosh lists 22 colour names, 11 behaviour names and 11 horn names. These are selected from cattle names running into hundreds. No muhima knows how many cattle he possesses, but if one is missing he will know because of the name; he has, then, only to tell the name of the beast to the Chief and it will be recovered for him. The colour names vary from the traditional red to pure white, black, grey and intermediate colours. Horn shapes vary from the traditional enormous spread, up to six feet in width, to polled animals and ones with loose horns hanging down close to the head (scurs). While the type species is straight-backed as stated by Mackintosh, he also states a hump may be preferred on the bulls but not on the cows. From these wide variations, it is clear that the Ankole cattle have become mixed to a considerable extent with Zebu and are no longer typical of the long-horned parent breed. The original herd bull at Whipsnade has a very definite hump, and the short neck and deep dewlap of the Zebu. He is transmitting these characteristics to his progeny.

It must be accepted, therefore, that whereas on the one side—the Aberdeen Angus—we are dealing with a fixed breed, on the other we are dealing with one that is mixed.

The pedigree of the young animal under study was as follows:—



The date of birth was 28-7-56, killed 25-11-57, thus the age was 16 months.

Conformation

The conformation data in Tables I and II have been compiled according to F.A.O. (1953) "Manual of Field Studies on the Heat Tolerance of Domestic Animals". Comparable measurements are given for an Ankole bull from Whipsnade, one animal of West African shorthorn breed and for a bull and a cow of Fulani Zebu breed. (Fiennes, unpublished data).

The horns of the Ankole cross were short and thick and similar to those of a young Ankole bull. It had two temporary incisors on either side. Width of the hocks was 9½ in.

The horns of the pure Ankole were thick from base to tips, tapering evenly to points. They curved upwards, forwards and inwards; circumference at base 1 ft. 5¾ in., length on outer curve 2 ft. 4½ in.

Carcass Appraisal

Details of carcass appraisal are given only for the Ankole cross bull, since the pure Ankole bull was an adult and thus was not suitable for comparison. The liveweight of the Ankole cross was 280 kg. and the dressed carcass weighed 155.75 kg., giving a dressing percentage of 55.5 per cent. The weights of offals are given in Table III.

Table III

	kg.
Dry hide	30
Four feet	5
Caul fat	1
Mesenteric fat	½
Alimentary tract (full)	57
Alimentary tract (empty)	25
Liver without gall bladder	4½
Heart	2
Head (with brain)	12
Brain	½

Table I—Body Measurements

Breed	Weight	Length	Height	Chest depth	Hips width	Heart girth	Foreleg length	Dewlap depth
	lb.	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*
A/A.A.	616	46	42	19	17	61	26	2½
Ankole bull	1,061	63	59	30	16	82	36	5½
Ful. bull	1,140	55½	59*	26	18	74½	35	11½
Ful. cow	872	52	51*	23	17	69	34	6½
W.A.S. bullock 15 months	416	45	40	19½	13	56	28	2

*Height in all cases is taken to the top of the hump. The Fulani bull and cow and the Ankole bull were all adults.

Table II—Condition of Integument

Breed	Hair condition	Skin condition	Skin pigment	Coat colour	Munsell value†
A/A.A.	Soft short	loose 12 mm.*	Red	Dark reddish-brown	5 Y.R. 2/2
Ankole bull	Soft short	loose 14 mm.	White	Dark reddish-brown	5 Y.R. 2/2
Fulani bull	Soft short	loose 21 mm.	Black	Light grey	10 Y.R. 7/2
Fulani cow	Soft short	loose 10 mm.	Black	light brown-grey	10 Y.R. 6/2
W.A.S. bullock	Soft short	v. loose 9 mm.	Light black	White, black flecks on head, black ears	7·5 Y.R. 8/0

*Double width on neck taken with tuberculin calipers.

†According to the Munsell Soil Colour Chart.

The weights of the various joints, and the percentages, compared with those from a good standard European carcass, are given in Table IV.

TABLE IV

	Weight kg.	Percentage	
		Ankole/ Aberdeen Angus	Good European Carcass
Round (including cod fat and skirt) ..	29·0	18·5	16·0
Pubic bone	1·0	0·65	0·7
Loin	14·5	9·2	12·0
Suet and kidney ..	2·5	1·6	
Crop (10 ribs) (fore-rib, M. rib and steakmeat) ..	35·0	22·5	27·0
Clod and sticking ..	17·25	11·1	8·5
Flanks and Brisket ..	22·75	14·8	14·0
Legs and Shins ..	12·25	7·85	7·1
Rump	12·0	7·8	9·0
Thick flank	9·5	6·0	5·4
	155·75	100·00	

Carcass measurements in millimetres are given in Table V.

TABLE V

millimetres

	Right	*Left*
Body length	1055	1065
Loin	545	550
Width (body) ..	595	565
Fore-arm length ..	327	330
Leg length	620	623
Fat (cut edge) ..	407	414
Tibia length	360	360
Eye muscle:—		
A. 105		
B. 58		
C. 4		
D. 3		

COMMENTS BY MR. FRANK GERRARD, REGIONAL HEAD, NATIONAL COLLEGE OF FOOD TECHNOLOGY

Report on Ankole/Aberdeen Angus

"It is possibly a little difficult to give a direct evaluation of this particular animal in comparison with the normal type of *castrated* male but the following general points might be of interest.

Ignoring the fact that this was a bull, my general evaluation of the carcass, as compared with the normal run of commercial beef, was approximately 55 per cent. The most striking feature was the lightness of bone and, although there was considerable shankiness, the Round, as such, was reasonably thick and deep. The heavy development of the muscle in the rump region has already been noted. It was difficult to assess to what extent the somewhat heavy neck and crest muscle was due to breed or sex. The neck was short with a relatively sharp upward turn of the cervical vertebra in relation to the dorsal. The kidney suet was extremely light although there was some slight deposition of fat in the chest cavity on the pleura. Considering that it was a young bull, the proportion of hindquarter to forequarter was particularly high, at over 52 per cent, and it would be interesting to obtain figures from a similar carcass of a steer or bullock. The colour of the flesh generally was slightly dark, the texture reasonably good with some slight semblance of potential marbling fat in the muscle of the loin. The fat was white in colour, almost resembling that of mutton fat and, as far as one could judge, the ossification of the *os pubis* and spinal processes had taken place more rapidly than one would normally anticipate in a domestic breed of this age.

The figures attached* represent the approximate weights and percentage of the various joints and, for general information, I have also given those which might be expected from a reasonably good English body of beef. The most outstanding contrasts would appear to be the development of the Round, the lightness of the crop and the small figure of the pubic bone, which is thought to give some indication of the total bone content. It will be noted that the Clod and Sticking is a considerably higher percentage than the standard."

GENERAL DISCUSSION

The study of this small bull was undertaken with a view to assessment of retained native characteristics of climatic value in the tropics, together with features of value to carcass quality acquired from the European breed. Obviously the work on this one animal, extensive as it was, is of little value *per se*. The work has, however, revealed that no standard methods exist by which conformation studies may be made which combine climatic and economic suitability. The idea that initial crossing experiments might be made in European countries, away from the hazards of tropical disease, is an attractive one; this is incapable of accomplishment in the absence

*The data referred to are given in Table IV.

Plate 1.—The crossed Ankole/Aberdeen Angus bull immediately prior to slaughter

Plates 2, 3 and 4.—Carcass characteristics.—Fiennes Ankole/Aberdeen Angus bull

of established criteria by which the crossed products may be appraised prior to testing overseas.

Most careful and detailed standards have been recommended by the Food and Agriculture Organization of the United Nations for climatic studies, but no attempt has been made to link these with work on carcass evaluation. This rests largely on the work of Hammond (1955) done at the Cambridge School of Agriculture. Pomeroy (1958), who is concerned with Hammond in this work, states that Hammond's published criteria are now subject to revision, with the result that there are no accepted methods of carcass appraisal which could be recommended to field workers. He makes the further point that standards acceptable in this country might not be acceptable in consuming countries in the tropics. Methods for the evaluation of chilled beef carcasses have been evolved in New Zealand and are described by Kneebone *et alii* (1950); however, these do not appear to be accepted in the United Kingdom.

The work described here could certainly not have been done without expert assistance over carcass evaluation. Such assistance will not normally be available to most workers, and there is an obvious requirement for an internationally accepted standard, whereby the general quality of beef carcasses can be judged; this should be of sufficient simplicity to be operated by the field worker in conjunction with a butcher of normal competence.

In the present instance, it would appear that this animal with one quarter Angus blood and three-quarters Ankole showed surprisingly high qualities as a beef animal, certainly far higher than the parent Ankole strain. Nevertheless, the general conformation—apart from a shortness of the foreleg—was that of the Ankole. Potentially, the cross would appear to be worthy of trial under African conditions. Nevertheless, it is not wished to draw conclusions from this one essay, the value of which lies in the attempt to combine two essential methods of study.

Additional Data

Skin samples from the crossed bull were sent to Dr. Findlay at the Hannah Dairy Research Institute; they will be reported on by him separately.

Blood was sent to Dr. Bangham at the Institute for Animal Physiology at Babraham. He reports that the bull's blood was homozygous Bovine haemoglobin A. He comments that Jersey, Guernsey and Zebu very often have the allele Bovine B.

Acknowledgments

We are greatly indebted to Dr. Pomeroy who came to Whipsnade with us from the School of Agriculture at Cambridge, and also to Mr. Frank Gerrard who also devoted the greater part of a day to assisting us. I should also mention the efficient co-operation of Mr. Martin Senior, M.R.C.V.S., Hon. Veterinary Surgeon to Whipsnade. We were also assisted by Mr. Brooms of F. M. Brooms, Dunstable, Butchers. Photographs were taken by Messrs. Turkey and Bailey, Dunstable.

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THE RIVER FISHERIES OF KENYA

I—NYANZA PROVINCE

By P. J. P. Whitehead, Ministry of Forest Development, Game and Fisheries, Kenya

(*Received for publication on 7th January, 1959*)

An investigation of the river fisheries of Nyanza Province (1955-57) has shown that there is a large and heavily exploited source of fish, the estimated annual yield of which exceeds 2,000 tons. The Kenya river fisheries as a whole may thus rival the marine fisheries in size. Preliminary findings, after a year of observations, were discussed in an Interim Report (Whitehead, 1956), in which, however, it was stressed that further biological work was essential before accurate recommendations could be safely made. A second year of observation has now amply confirmed the initial overall impression, viz. increasing exploitation and, by excessive destruction of potential breeding stocks, a trend towards diminishing returns. Since such a situation parallels that found on Lake Victoria itself, it is not difficult to predict the final outcome on the rivers should conservation measures be delayed.

The river fisheries and those of the lake are both complementary and closely linked. Thus the majority of river fishes, while spending much of the year in the main lake, play a remarkably small part in lake gillnet catches. On the other hand any biological disturbance on the main lake will have direct effect on the river fishes and thus on the fisheries also. The river fisheries depend on the active migration of anadromous, and mainly non-cichlid, fishes up rivers to spawn during the rains; the lake fisheries on the other hand rely primarily on the random movements of a single cichlid species, *Tilapia esculenta*, peak catches occurring in the dry seasons. Finally, while *T. esculenta* has to a large extent captured the non-African market, and thus commands a relatively high price, the river fishes tend to satisfy local African requirements, and are correspondingly cheaper. The lake and river fisheries are, however, intimately connected through complex ecological relationships existing in the main lake, and future policy and research should recognize this.

The Rivers of Nyanza

All natural bodies of water in Nyanza Province which discharge into Lake Victoria were considered, but in practice the lower reaches of large rivers proved to be the most important to the fisheries. Distances precluded regular recording from much of South Nyanza, including the Kuja river.

The Province contains eight natural drainage basins—those of the Nzoia, Kuja, Sondu, Yala, Kano plains, and the north and south borders of the Kavirondo Gulf. Since the fisheries are based on migratory fishes from Lake Victoria, the size and nature of the outlets from these basins largely governs the size of the fisheries. Artificial drainage of river mouth swamps, or the accumulation of papyrus, will quickly affect the fisheries. At the present time the Yala river is totally blocked by a large swamp, but the Nzoia, Kuja and Sondu rivers have open mouths. The Sondu river fisheries are, however, restricted to the lower five miles, a large waterfall preventing further ascent by anadromous fishes.

Of great importance to the fisheries are the floodwater pools which line the floodplain in the lower reaches of the larger rivers. Many river species breed there, and the channels connecting such pools to the river provide ideal trapping opportunities for the fishermen.

Very many temporary streams and swamps occur throughout the Province and these become seasonally important to the fisheries.

Recording stations were set up at two points on the Nzoia river, and at one each on the Sondu and Yala rivers. African staff visited all major fishing centres, including the lake area opposite the mouths of large rivers.

The River Fishes

Recently the fishes of the Lake Victoria region have been reviewed by Greenwood (1955-57). All species likely to be encountered in Nyanza rivers are listed with excellent descriptions and keys.

The most important migrant to Nyanza rivers is the *fwani*, *Barbus altianalis radcliffi*, a species which commonly attains 7 lb. The *fwani* is caught in lake and river 5-in. gillnets, as well as in river barrier traps (*kek*), lines and in clasp nets.

Second in importance is the *ningu, Labeo victorianus,* a smaller fish (1-3 lb.), but one which is caught in considerable numbers in *oloch'wira* traps, in baskets, in 2½-in. gillnets and in *kek.* Similar to the *ningu* in size, habits and method of capture, is *Schilbe mystus,* the *sire. Tilapia variabilis,* the *mbiru,* is the only cichlid of importance to the river fisheries, and indeed is one of the most abundant species caught in lower river *kek.*

Of the remaining species, many are small, but may be caught in quantities by means of scooping baskets (e.g. *Alestes nurse, Synodontis* spp., several mormyrids and many *Barbus* spp.). Other species may attain a large size (e.g. *Clarias mossambicus,* 10-15 lb.; *Bagrus docmac,* up to 30 lb.; *Protopterus aethiopicus,* 10-20 lb.) but are not common.

Although African preference is undoubtedly for large fishes, there exist several trapping methods adapted solely for the capture of small or juvenile fishes, which are cooked and eaten *en masse.* No widely held prejudices were found concerning the palatability of any species, but mormyrids are occasionally viewed with suspicion.

Fish Migrations

Purely riverine fishes are rare in Nyanza; the majority of species caught in rivers are anadromous, spending most of the year in the main lake but ascending rivers to spawn. Anadromesis is thus of considerable importance to the river fisheries. This subject has been examined in some detail elsewhere (Whitehead, 1958*b*), and the following is a summary of the main points.

In response to certain physical and chemical properties of river floodwater, the anadromous fishes ascend rivers to breed. The exact flood conditions required vary between species, and variations in the different stimuli involved (water height and velocity, turbidity, concentration of dissolved salts, temperature, pH, etc.) appear to act in combination, one factor being compensated for by another under certain circumstances. Although precise determinations of specific requirements would involve a great deal more research, it can be said that normal, moderately high floods, will produce all the conditions required by the various anadromous species for breeding.

Three migratory patterns have been recognized, long, medium and short, depending on the duration and distance involved. *B. a. radcliffi* belongs to the first category, travelling as much as 70 miles up river. *Labeo* and *Schilbe* belong to the second group, and *Alestes* to the third. Ultimately these migratory patterns are governed by the location and nature of the spawning grounds, e.g. rocky upper reaches, inundated flood pools, small streams, etc. Although precise spawning grounds are still unknown for many species, all will be available under average flood conditions.

It follows, therefore, that any deviation, whether natural or artificial, from normal flooding régimes will affect river catches immediately, while destruction or modification of breeding areas will jeopardize future stocks. Unfortunately irrigation projects, water control and hydro-electric schemes offer a threat to both migration and breeding.

River Fishing Methods

The many and ingenious fishing devices used by river fishermen in Kenya have been described elsewhere (Whitehead, 1958*a*). The main methods found in Nyanza are:—

Kek.—A barrier of sticks often reinforced with stones, built entirely across rivers, incorporating a series of non-return fishing devices. The latter may be in the form of baskets, enclosures or funnels.

Oloch'wira.—Circular maze-like enclosures with funnel entrances, built on the flood plain.

Baskets.—A large variety are used, either for scooping or trapping.

Gillnets.—Both 5 in. (for *fwani*) and 2½ in. (for *ningu* and *sire*) are used in the lower parts and at the mouths of large rivers.

Lines.—Long lines, employing up to 600 hooks, are used in small lakes, especially in the Yala swamp area. Rods are used in the rivers for catching *fwani.*

Claspnets.—Used for catching *fwani* near waterfalls.

Formerly the organization of the river fishing industry (ownership, riparian rights, obligations, etc.) was basically a reflection of those family, clan and tribal relationships characteristic of a primitive agricultural economy, but with the present loosening of such ties the fishing industry, too, has become more pliant and susceptible to innovation, particularly where production for profit rather

than use is involved. In the case of *kek*, however, the old methods are still fairly rigidly preserved.

Of the fishing devices listed above, almost all rely on the active movement of fishes towards the breeding grounds, since at this time the fishes are concentrated into shoals which readily enter baskets or enclosures; the post-nuptial dispersion is less compact. The result is that a comparatively small number of fishes ever reach the breeding grounds. But while adequate breeding might be achieved through the successful spawning of even this fraction, recruitment is further jeopardized by intensive fishing for juvenile fishes, particularly in the floodwater pools.

Yields

The following figures are derived from samples taken two to four times a week from various fishing methods during 1955-57. Such figures are of the utmost value, being first of their kind from any East African river fishery, and they will provide a reliable base-line for assessing the stability of the industry.

Kek

During normal years on the Nzoia river *kek* are operated for two 12-week fishing seasons. At the Hainga *kek* an average of 45.7 upstream traps were operated daily during the fishing periods recorded, each trap catching an average of 7.97 lb. of *fwani*, and 15.54 lb. of other species per day. This would give an annual yield of 24.3 tons of *fwani*, and a total of 77.5 tons of all species combined.

While the Hainga *kek* catches mainly upgoing migrants, the *kek* at Luambwa, ten miles further up the Nzoia, is concerned mainly with returning fishes. The *fwani* is rare and *ningu* predominates. Catches are lower (2.44 lb. per basket per day) and, with an average of 46.0 baskets in use daily, an annual yield of 8.42 tons is estimated.

On the Nzoia river there are three further *kek* similar to that at Hainga, and two more resembling the Luambwa *kek*. Total *kek* catches for the Nzoia would thus be 335.3 tons per year. This does not take into account the *obalalo* type of *kek* in the upper Nzoia, of which there are at least 20, estimated to yield a further 10 tons.

The Kuja river probably yields almost as much as the Nzoia (about 300 tons) and the Sondu river about a half.

Gillnets

On the Nzoia river 134 different 5-in. gillnet fishermen were recorded, whose average daily catch was 8.4 *fwani*, weighing 13.1 lb. The normal season is about 20 weeks, during which one man would catch 4,774 lb., and 134 men 250 tons. While not every man fished every day, many went unrecorded, so that 200 tons is considered likely. Sondu river catch rates rival those of the Nzoia, and the Kuja undoubtedly produces a similar yield, so that 5-in. gillnets probably yield about 600 tons per year.

Lake gillnetting opposite the mouths of flooding rivers is essentially a part of the river fisheries. During 36 recorded weeks an average of 95 nets were set daily by 60 fishermen in canoes, catching 2.54 lb. of *fwani* and 4.08 lb. of other species per net per day. It is estimated that 230 tons of fish were caught in the two 12-week fishing seasons. Similar yields can be expected from the Kuja and Sondu rivers. Some 390 2½-in. nets were also in daily use, yielding altogether 866 lb. of *ningu* and 90 lb. of *sire* per day. The 2½-in. nets outside the mouth of the Nzoia probably yield about 4 tons per year, or 12 tons for the three main rivers.

Oloch'wira

Few floods reached the high level *oloch'wira* (which predominate), but by analogy with *oloch'wira* closer to the river, an average of 30 fishes (14 lb., mostly *ningu*) can be expected daily during the short two-three-month season. Nearly 200 *oloch'wira* line the banks of the Nzoia, and more than double that number lie inland, so that in a year of high floods about 200 tons of fish will be caught on the lower Nzoia floodplain, and an average of about 100 tons may be expected in normal years. A similar production can be expected from the Kuja river, and about a third of this from the small Sondu river floodplain.

Line Fishing

The most complete figures are those for the Sondu river, where 66 fishermen caught an average of 268 *fwani* daily, during a nine-month fishing season, each fish weighing 2.13 lb. This catch rate would give an annual yield of 428 tons. On the Nzoia river the records suggest a slightly lower catch rate, but over the 70 miles fished the annual yield is certainly no less than on the Sondu river. Line fishing is also intensive on the Kuja river,

where yields are probably similar to those of the Nzoia. Line fishing may thus yield 150 tons of *fwani* throughout Nyanza.

Baskets

Baskets of many varieties are widely used in Nyanza, in rivers, streams, swamps and floodwater pools. Records from the Nzoia river basin suggest yields of about 8 tons per year. Similar figures might be expected from the Sondu and Kuja rivers, while the numerous small bodies of water elsewhere in the Province probably yield a further 4 tons.

TABLE I—TOTAL YIELDS IN TONS

METHOD	Nzoia	Kuja	Sondu	Others	Total
(*a*) *Kek* ..	335	300	150	—	785
(*b*) Obalalo ..	10	—	—	—	10
(*c*) River Gill-nets (5″) ..	200	200	200	—	600
(*d*) Lake Gill-nets (5″) ..	280	280	280	—	840
(*e*) Lake Gill-nets (2½″) ..	4	4	4	—	12
(*f*) *Oloch'wira*	100	100	30	—	230
(*g*) Baskets ..	8	4	4	4	20
Total ..	937	888	668	4	2497

Table I shows that the river fisheries of Nyanza produce approximately 2,500 tons of fish annually, which, if valued at Sh. 1 per pound, represents a value of £280,000. Distribution of river fishes is carried out mainly by individuals on bicycles, the fish being taken to African markets up to 20 miles away. About half the catch is, however, consumed locally.

THE STABILITY OF THE INDUSTRY

The river fisheries of Nyanza are threatened by two main dangers.

Over-Fishing

The overwhelming preponderance of unspawned fishes in river catches must inevitably result in a reduction of breeding stocks, perhaps below a safe limit. If the yields are already declining—and only continued records can show this—then it is almost certain that the comparatively recently introduced gillnet has tipped the balance, since gillnets are now responsible for over half the total catches in Nyanza. Undoubtedly *kek* catches were much higher before the introduction of gillnets into the rivers, but at the same time gillnets have enormously increased the total catch since they are operable at all flood levels. *Kek*, on the other hand, tend to be over-topped and broken at the height of most floods. Gillnets could be prohibited completely, but they represent a simple method when compared with the cumbersome *kek*. Removal of *kek*, however, would deprive the fishermen of many of the smaller species of fishes not caught in gillnets; such smaller species comprise 75 per cent of *kek* catches, or about 600 tons of fish a year.

The best solution would be a once weekly closure of the river to gillnets and at the same time the allowance of one or more permanent free passages in each *kek*.

Modification of River Régimes

As explained above, alterations in river régimes may directly affect migratory behaviour, or may, indirectly, alter or destroy spawning areas. In Nyanza three types of project threaten the fisheries.

Irrigation Schemes.—A comprehensive report has been issued by Sir Alexander Gibb and Partners on this subject (Gibb, 1956). This report makes it clear that many of the conditions required by anadromous fishes cannot be maintained on rivers serving irrigation schemes (van Someren, 1957). Thus storage of river flood water will both eliminate sudden floods and will alter the composition of the relatively pure floodwater. Levées and swamp draining will destroy low-lying flooded breeding sites. Barrages will interfere with upstream migrations.

Hydro-electric Schemes.—Any form of barrage in the lower reaches of Nyanza rivers will prevent the ascent of anadromous fishes, unless special fish-ladders or passes are installed. Such a ladder has been constructed at the Gogo Falls hydro-electric installation on the Kuja river. Experience has shown that the cost of ladders, or preferably passes, is greatly reduced if they are designed as part of the main dam and not added later, and this should be insisted on in future.

Pollution.—The discharge of mining or industrial waste products is fortunately rare in Nyanza, but pollution does occur in the Kuja river as a result of waste products from the Macalder-Nyanza copper mine. Heavy fish mortalities have been reported, and water samples suggest that concentrations of zinc, arsenic and cyanides may reach toxic levels in the dry seasons. Whatever the eventual dilution of toxic elements further down the river, anadromous fishes must still pass the vicinity of the effluent, so that maximum concentrations must be considered.

Discussion

Freshwater fishes do much to restore the dietary balance in areas where starch and cash crops predominate and where cattle are still regarded more for their numbers than for their quality. In this context river fisheries play a particularly important role. Their occurrence follows the pattern of drainage, and thus of settlement, so that transport and distribution costs are at a minimum. In addition the yield per acre is extremely high, since even in fish ponds a yield of 400-500 lb. per acre can be achieved without supplementary feeding or fertilizers, compared with about 200 lb./acre/annum for prime beef off good pasture in Europe (Worthington, 1943). In Nyanza Province river fishes do not command a very high price (less than a shilling per pound), so that their importance as a relatively cheap form of animal protein far outweighs their value as a cash crop.

The total yield of river fish from Nyanza is large (2,500 tons), but it appears to be derived at the expense of future stocks, if the preponderance of unspawned fishes in catches is any indication. Certainly river gillnets now catch many tons of fish which previously escaped when the *kek* were overtopped. The closure of rivers to gillnetting for one day a week, and the provision of free passages in all *kek*, would relieve at least some of the present pressure on spawning runs. Obviously successful spawning is equally dependent on conditions in the breeding grounds, and the maintenance of permanently flooded areas adjacent to the river, and if possible the prevention of fishing in such nurseries would ensure that the fullest use is made of those fishes which escape capture in *kek* or gillnets. Such measures would, however, depend mainly on the co-operation of the fishermen themselves, coercion being a notoriously poor substitute for enthusiasm.

The effects on the river fisheries of water control for irrigation or hydro-electric schemes must be borne in mind. Control of floods will undoubtedly have an adverse effect on those migrants which apparently require high river conditions, either for migration or for making available the breeding grounds (e.g. *Schilbe* and *Labeo*). Through co-operation between agricultural and fishery interests, *before* such schemes are initiated, some degree of compromise can probably be reached whereby provision can be made for fish passes, artificial "freshets", maintenance of some spawning areas, return of juveniles to the main lake, and so on.

The data on which the present yield estimates are based cover a period of, at the most, 18 consecutive months. Owing to the probable long life of the major migrants and year-to-year fluctuations in the size of the spawning runs, the trend of the river fisheries will not be apparent until at least five years of records are at hand, probably more. In the meantime one can only hope that conservation measures can be introduced in time to maintain the present high yields while guarding against over-exploitation.

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VARIATIONS IN LIVEWEIGHT OF CATTLE ON FARM AND RANCH IN TANGANYIKA

By H. G. Hutchison, Veterinary Research Laboratory, Mpwapwa, Tanganyika

(*Received for publication on 31st December, 1958*)

During the course of practical training of African Veterinary Assistants for livestock recording duties the students were required to conduct two simple experiments to observe the extent of the variations in liveweights of cattle kept under two extreme conditions of natural husbandry in Tanganyika. The records collected have been treated statistically and may be of interest to breeders who keep liveweight records of their cattle.

Material

Group 1—Indigenous Zebu Cows on Good Farm Grazing

Six adult indigenous Tanganyika shorthorned zebu cows, without calves, were under observation from 7.00 a.m. until 5.30 p.m., during May (towards the end of the wet season) at the Veterinary Research Farm, Mpwapwa, in the Central Province of Tanganyika. At night the cows were kept in a concrete yard where permanent water was available to them as required.

By day they had ample green grazing in paddocks within half a mile of a weighbridge. They were weighed when they left their night quarters at 7.00 a.m., again at 10.00 a.m., at midday, just before and after watering at about 2.00 p.m., at 3.30 p.m., and at 5.30 p.m. before returning to their night quarters. No food was available to them other than grazing, and all cows were improving in condition during the period.

In addition to weighing the animals the students were required to record each occasion on which the animals urinated or defaecated during the daytime observation period.

Observations were made on nine days during a period of 13 days, and weights were measured on a steelyard-type weigh-bridge, weighing to the nearest one pound.

The mean morning weights of the six cows during the period were 543.6, 492.4, 482.2, 473.6, 396.6 and 353.9 lb., respectively.

Group 2—Ranch Cattle under Very Severe Dry-season Conditions

Ten cattle used in this investigation at Matamondo Ranch in Central Province, Tanganyika, were observed during a period of 19 consecutive days, during the dry season in August, at a time when grazing was exceedingly scarce.

The cattle observed included five pairs of animals each representing a different breed type. One was a bull, four were heifers and five were cows.

All cattle were confined to stockades from 6.00 p.m. to 6.30 a.m., adjacent to the weighbridge and watering point. They went to graze in areas varying from one to two miles from the stockade. They returned for weighing and watering at midday approximately, and then returned to grazing until the evening.

Weights were recorded when leaving and returning to their night quarters and immediately before and after watering at midday. Unrestricted watering was allowed during a period of about 30 minutes at the water trough.

The bull received about 20-30 lb. of cut green elephant grass in the evenings, but the females received no supplementary feed.

Weighing was done on a large dial-type weigh-bridge graduated in 5-lb. units, but weights were estimated from the scale divisions to the nearest pound by the recorder.

The mean morning weights of the ten animals during the period were 932.2 lb. and 868.3 lb. (Africanders), 758.5 lb. and 748.3 lb. (Herefords), 778.8 lb. and 666.8 lb. (Borans), 580.3 lb. and 560.2 lb. (indigenous Tanganyika shorthorned zebus), 667.0 lb. and 573.7 lb. (Hereford-indigenous crossbred heifers).

Some animals were losing weight and others were maintaining weight during the period. The regression of all weights on days over the period showed an average daily gain of 0.1 lb. per animal.

In neither group was any particular attempt made to reduce variations between weighings and the animals were permitted the degree of freedom which they would normally enjoy under a system of general grazing control.

Results

Table I—Mean Weights, Weight-Changes, and Standard Deviations of Liveweights taken at Different Times of Day and Expressed in Pounds

Time of weighing (approximately)	Mean liveweight	Mean gain or loss since previous weighing	Standard Deviations of Weights Attributable to: Day-today variations after correction for growth trends	Uncontrolled individual variations	Pooled day-to-day (corrected) and uncontrolled individual variations
1	2	3	4	5	6
7.30 a.m.	457·0	—	−1·9‡	7·5	7·3
9.30 a.m.	464·6	+7·6	−0·6‡	7·2	7·2
11.30 a.m.	471·7	+7·1	2·4‡	5·9	6·3
1.30 p.m.	473·0	+1·3	6·9†	7·3	9·8
2.30 p.m.	490·1	+17·1	2·6‡	6·1	6·6
3.30 p.m.	492·9	+2·8	3·8*	5·1	6·2
5.30 p.m.	493·9	+1·0	5·2†	4·4	6·6

Group 1.—Good farm grazing, wet season, water available at night, 6 indigenous cows gaining 1·9 lb. per day

Time of weighing (approximately)	Mean liveweight	Mean gain or loss since previous weighing	Standard Deviations of Weights Attributable to: Day-today variations after correction for growth trends	Uncontrolled individual variations	Pooled day-to-day (corrected) and uncontrolled individual variations
1		3	4	5	6
7.00 a.m.	713·4	—	4·9†	6·5	8·1
Midday	714·4	+1·0	5·8†	6·1	8·3
1.00 p.m.	763·5	+49·1	8·6†	8·5	12·0
5.30 p.m.	755·5	−8·0	5·6†	7·1	8·9

Group 2.—Very poor ranch grazing, dry season, no water at night, 10 animals of five breed-types gaining 0·1 lb. per day

Column 4 is derived from the mean square of the deviations from the regression of weight on days, less the error mean square, and divided by the number of cows. Negative values can be regarded as estimates of insignificant day-to-day variation.

Column 5 is the square root of "cow-day interaction" mean square from analyses of variance into components for "cows", "regression of weight on days", "deviations from regression", and "cow-day interaction".

Column 6 is the square root of the mean square derived from the pooled sums of squares for the last two components in the above analyses of variance.

*Indicates statistically significant at $P < 0{\cdot}01$.

†Indicates statistically significant at $P < 0{\cdot}001$.

‡Indicates *not* statistically significant.

In Table I the mean liveweights of the two groups of cattle at each weighing time during the day, for the whole observational period, are shown in column 2, and the mean gain or loss in weight of each group between one weighing and the next during the day is shown in column 3. These changes reflect the variation in weight of the contents of the digestive system during the day.

The availability of water during the night and the abundant grazing by day are partially responsible for the less extreme diurnal variations among the weights of the farm group than among the ranch group which had only one opportunity, at the midday watering, to consume any substantial weight of material.

The magnitude of the variations in weight at different times is sufficient to cause considerable errors in comparisons of weights of animals which have to be weighed at different times of day, even on the same day, as must occur when large numbers of cattle are being

weighed in consecutive groups in order to reduce loss of grazing time. Comparisons between animals weighed in the morning and those weighed in the afternoons will be subject to an error estimated as the accumulative total of column 3 between the two times of weighing, provided that the normal routine of the farm or ranch is followed by herds while they are not being weighed.

The greatest cause of weight change during the day was water intake and loss, and the frequency of urination and defaecation tended to increase sharply during the two hours following midday drinking.

If animals have to be weighed over an extended period of time on any one day it would be desirable to withhold water during the preceding night and to complete all the weighings before the animals have access to water on the day of weighing.

To determine which time of day is most suitable for weighing cattle if comparisons have to be made between weights recorded on different days, analyses of the variance of the liveweights throughout the observational period were made in respect of weights recorded at each time of day separately.

In each case the total variance of liveweights at each weighing time was analysed into the following components:—

(i) variations due to differences between the mean weights of individual animals over the period (five degrees of freedom in Group 1, and nine in Group 2);

(ii) variations affecting the whole group of animals and causing the day-to-day average weight to vary. This component was further subdivided into:—

(*a*) variations attributable to the general growth trend of the whole group during the observational period (the regression of weight on days with one degree of freedom);

(*b*) variations due to conditions affecting the whole group at weighing time from day to day other than growth trends (the deviations from regression of weight on days with seven degrees of freedom in Group 1 and 17 in Group 2); and

(iii) the remaining variations in the weights of individual cows on different days unaccounted for by (i) and (ii) (cow-day interaction with 40 degrees of freedom in Group 1 and 162 degrees of freedom in Group 2).

The differences between mean weights of individual cows are dependent on the variability of size among the animals being weighed, and such variations do not directly concern the accuracy of the weighing procedure. With the very variable groups used in these observations there were naturally very significant differences in weights between individuals at all weighings, but these differences are only of interest in this study in so far as the capacity of the animal to ingest food and water is related to size. This aspect will be discussed later.

The differences which arise between the mean weight of the whole group recorded at the same time of day on different days will include a measure of the progressive growth or loss of condition of the animals during the period between recordings. It is to measure this trend that the practice of routine periodic weighing is undertaken. In this study we are not concerned with the degree of this trend but with the inaccuracies to which estimates of the trend are subject. Some of these inaccuracies, represented by component (ii) (*b*) above, will involve the day-to-day average weights of all animals weighed at a particular time due to such influences as:—

(i) weight of moisture clinging to the coat shortly after dipping or rain;

(ii) unusually large or small intake of water or food owing to changes in management or pasture;

(iii) unusual variation in excretion of waste products as a result of particularly costive, laxative, or diuretic diet, or extreme climatic variation; and

(iv) errors in adjusting the zero setting of the weigh-bridge before commencing weighing.

The relative magnitude of such variations at different weighing times are indicated in Table I, column 4. Under farm conditions there were insignificant variations during the short period of time covered by observations during the main grazing hours. The very highly significant variation at the 1.30 p.m. weighings on the farm was attributable to the cows having access to water from an open drain just before the intended watering on one occasion. Immediately after watering on the farm there was no significant variation from

day to day, but later in the afternoon the day-to-day variations increased, probably as a result of differences in grazing behaviour due to several heavy rainstorms, and to the direct effect of the rain.

If observations had been prolonged over several months it is reasonable to suppose that significant day-to-day variations would have affected records at all times of day owing to the variation in pastures, climate and management practices which are inevitable over long periods of time.

Under ranch conditions there were very highly significant differences between day-to-day weights at all times of day. Owing to the sparcity of grazing and the varying distances and areas covered in search of grazing during the period such variations were to be expected at all weighings after the first, but it seems doubtful whether the intake of the previous day could explain the relatively small but highly significant differences on the following morning after being confined for the night in a bare stockade. Unexpected rainfall at dawn on two occasions contributed part of the early morning difference between days, but significant variations on two other days had no obvious cause, and the zero-adjustment of the weigh-bridge must be suspected in the absence of any more likely cause of variation. Apart from these four occasions the variance at morning weighings was not significant.

While weighing a larger group of animals under ranch conditions during rain showers, a comparison of weights of the same animals weighed within one hour immediately before and after the rain showed an average increase of 9.7 lb. for 19 short-coated Boran-type cattle, whose average dry weight was 827 lb., after a short severe shower, and an average increase of 4.6 lb. for 17 similar cattle after exposure to drifting misty rain for about 30 minutes.

On the basis of day-to-day variations, within short periods of time, the available data indicates early morning as the time of day when weights are least likely to be biased by day-to-day effects under either ranching or farm conditions, provided that the animals are enclosed, without food, at night.

The third component of the variance, which is presented in column 5 of Table I as standard deviations for comparison with those in column 4, results from the errors of individual weighings, such as occur if:—

(i) habits of individual cows differ from the group trend from day to day; or

(ii) tare weight on the weighbridge is not accurately adjusted before each cow is weighed;

(iii) if individual weights are inaccurately recorded.

Assuming that the recorder is equally diligent at any time of day, this component of variance will largely reflect the opportunity which animals have had to exercise their individuality. In both the farm and ranch groups this variance was reduced to a minimum after periods of grazing but before drinking. Where water was more readily available on the farm, and smaller quantities were drunk at midday, the evening weighing showed the smallest individual error, but under ranching conditions the variability introduced by very large and very variable individual intakes of water at the single watering period persisted to the evening, so that the midday weighing before watering was the most accurate.

Whether the day-to-day, or the individual, source of variation is likely to have the greater influence on the accuracy of any particular set of comparative weights will depend on the circumstances of the specific comparison, but unless particular attention has been paid to reduce the day-to-day variations to negligible proportions the experimenter, or farmer, will usually have to contend with a composite error.

The composite error variance is represented by the remainder of the total variance in the weights after that due to the characteristic differences in weights of individual cows, and that due to progressive growth trends, have been removed.

This variation, due to the total of all sources of error, is presented as a standard deviation in respect of each weighing-time in column 6 of Table I. From these results it appears that the most suitable time for routine weighing of ranch cattle, which do not have access to water during the night, is in the early morning; but under farm conditions, where water is available throughout the night, greater accuracy can be achieved if weighing is delayed several hours. It seems probable that this improvement in accuracy results principally from the reduced influence of variable water intake just before leaving the night quarters, but a regular intake of grass to capacity of each individual may also be reflected in the

reduced variation. The very high variation at the 1.30 p.m. weighing at the farm was almost entirely due to the irregularity of unauthorized drinking prior to the recognized drinking time which has already been mentioned, but which could usually be readily avoided under strictly controlled conditions.

A statistical examination of the variation in the individual changes in weight between every weighing revealed that among the farm group there were no significant consistent differences between any individual cows in the general trends of weight change from weighing to weighing throughout the day, but that there were highly significant differences between individuals in their mean loss of weight between the evening weighing and the following morning weighing, which was attributed to the different watering habits of individual cows during the night.

Among the ranch group there were highly significant consistent differences in weight changes of individuals during the day and night as would be expected from such a very heterogeneous group of animals, but the morning grazing interval showed the least individual variation of weight changes.

After removing the variation in weight changes during the day attributable to individual habit characteristics, there remained very highly significant differences in mean weight-changes of the whole groups between different weighing-times, which reflects the differences in variable factors affecting the whole group at the same period of the day on different days.

In confirmation of the pattern of variation in absolute liveweights the pattern of variation in changes of liveweight showed the least degree of significance after grazing, but before drinking, and in the period immediately after drinking, in the farm animals, and was lowest during the night period in the stockade among the ranch animals.

Water Consumption

The changes in the weight of the cattle before and after watering provide an interesting estimate of the water intake. In the case of the farm group the total water intake could not be estimated owing to their unrecorded consumption during the night, but among the ranch group the total daily water consumption could be estimated closely from the change in weight between the two midday weighings.

The mean daily water intake of the ten ranch cattle (less weight of urination and defaecation losses during the watering period) are shown in Table II, column 3.

As one would expect the larger animals tended to consume more water, and the regression of the apparent water consumption on liveweight for the whole group was:—

b = + 5.76 lb. water per 100 lb. liveweight ± 0.90 lb.,

whence the prediction equation to estimate the water required by an animal of a given weight can be derived as:—

lb. water required = (liveweight × 0.0576) + 8.75 lb.,

or approximately 7 per cent of the liveweight.

Comparisons of actual water intake with the water intake predicted from this equation for each of the ten ranch animals are given in columns 5 and 6 of Table II.

Of the total sum of squares of deviations from the mean water consumption per animal over the period, 23.2 per cent was removed when correction was made for variations in liveweights. Of the remaining variance, 31.4 per cent was attributable to characteristic daily consumption of individual cows, quite apart from effects of their size, and 12.0 per cent was attributable to the influence of different days affecting the habits of the whole group, while the remaining 56.6 per cent of the liveweight-corrected variance was due to inconsistent consumption by individuals resulting from day-to-day influences peculiar to individual cows. Both the individual cow characteristics, and day effects on the whole group, were highly significant.

Discussion

It is probable that the uncontrolled variations in weights indicated in these results could have been reduced by additional care in weighing, by allowing wet animals to dry, by cleaning dirty animals, by checking tare adjustments more carefully, by closer control over the habits of the animals, and, perhaps, by greater precision in weighing. The results are, however, of considerable interest as an indication of the reliability of weighings carried out by "above average" African supervisory staff.

This reflection is not intended to disparage the efforts of Africans, many of whom are most dependable workers, but it is necessary to recognize that the investigational approach does not come naturally to many Africans of

the calibre of livestock assistants, and their basic education in elementary sciences is generally inadequate for them to consider the effects of influences which will impinge on investigational results.

The students making these observations were all of Tanganyika Territorial Standard VIII, or higher, general education, and had received instruction in the technique of recording livestock. They probably represent a better-than-average sample of the type of livestock assistant who could be economically employed at the present time by progressive stock-breeders and investigators in East Africa.

It is, therefore, worth while considering the relationship of the uncontrolled and day-to-day variations which are liable to occur in the liveweights of cattle, maintained and recorded under these East African conditions, to the numbers of observations it would be necessary to record before significant results from the comparison of different treatments which are expected to alter the liveweights of cattle could be reasonably anticipated.

If cattle have access to water during the night they should not be weighed until they have been away from water for at least five hours.

It is preferable that cattle which are to be weighed should be denied access to water during the preceding night and that they should then be weighed in the morning before they are watered or allowed to graze; but grazing alone does not introduce any great error provided all animals under comparison have equal access to the same grazing.

It is of major importance that all comparative weighings should be made at the same time of day on each occasion.

Under these circumstances single weights of individual animals will fall within about 16 lb. only of the true mean weight of the animal at about 95 per cent of the weighings, and this margin of error could be reduced by taking repeated weighings at the same time on several consecutive days. When repeated weighings are taken the margin of error will be reduced in proportion to the square root of the number of weighings.

From an investigational point of view comparisons of effects of treatments, or of rations, or of progeny of different bulls, etc., are often made between groups of several similar animals weighed before and after the treatments, or at certain ages. In Table III estimates, derived from these data, are presented to suggest the minimum number of cattle which would seem to be necessary in each group under comparison when the anticipated mean difference in liveweights of the groups resulting from treatment is expected to lie at various levels, and when the degree of significance of results are required at levels of 5 per cent and 1 per cent chance of erroneous conclusion.

These estimates are made on the assumption that all animals in the groups under comparison are similar and would normally be expected to react in a similar manner to the treatments imposed, and that the conditions affecting liveweights on the days of weighing are not more different than would be likely to occur between any two days within a short period.

In practice, it would be wise to allow a margin above these estimated minimum numbers for contingencies such as death, sickness, and seasonal trends; but by exercise of particular care during the weighing days a greater degree of reliability than that indicated could probably be attained, and the very heterogeneous types of cattle from which the ranch data were derived may have inflated the estimate of numbers required under ranch conditions.

Table III could also be used to derive estimates of the mean difference in weight which it would be necessary to achieve between comparative treatments involving a specific number of animals in each group in order to attain either degree of significance of results.

SUMMARY

Six indigenous Tanganyika shorthorned zebu cows were weighed seven times daily for nine days during the wet season under farm conditions, and five pairs of various breeds of ranch cattle were weighed four times daily for 19 days during the dry season by African student recorders.

Water intake is the greatest cause of variation in liveweight. Provided weighing is restricted to times at least five hours after watering, the standard deviations attributable to all causes of variation other than real differences between animals are of the order of 6.3 lb. for the farm animals, and 8.1 lb. for the ranch animals.

Water consumption by adult ranch cattle in the dry season is estimated at 5.8 lb. per

100 lb. liveweight plus 8.7 lb., or approximately 7 per cent of liveweight.

A table of estimated minimum numbers of cattle necessary to achieve significant results from various levels of mean liveweight differences resulting from different treatments of experimental groups of cattle held under conditions similar to those discussed is presented.

ACKNOWLEDGMENT

The data for this paper were collected by several students in training for livestock recording duties under supervision of Messrs. R. W. Woof, R. M. Mabon, and the author.

The Director of Veterinary Services, Tanganyika, has kindly given his consent to the publication of this paper.

TABLE II

	Midday Mean liveweight (lb.)	Water Consumption			
		Mean actual intake (lb.)	% of weight	Predicted intake (lb.)	Actual less Predicted intake (lb.)
1	2	3	4	5	6
1. Africander cow	932	62·6	6·7	62·4	+0·2
2. Africander cow	870	61·9	7·1	58·9	+3·0
3. Hereford bull	759	57·9	7·6	52·5	+5·4
4. Hereford heifer	747	60·5	8·1	51·8	+8·7
5. Boran cow	781	48·0	6·2	53·7	−5·7
6. Boran heifer	672	32·9	4·9	47·5	−14·6
7. Tanganyika zebu cow ..	580	53·0	9·1	42·2	+10·8
8. Tanganyika zebu cow ..	564	41·8	7·4	41·2	+0·6
9. Hereford x Tanganyika zebu heifer	669	41·7	6·2	47·3	−5·6
10. Hereford x Tanganyika zebu heifer	576	39·0	6·8	41·9	−2·9

TABLE III

Expected difference in lb. between means of comparative groups	Number of Animals Required per Group			
	Significance level 5% expectation of erroneous result		Significance level 1% expectation of erroneous result	
	Farm Cattle Wet season Weighed to 1 lb.	Ranch Cattle Dry season Weighed to 2·5 lb.	Farm Cattle Wet season Weighed to 1 lb.	Ranch Cattle Dry season Weighed to 2·5 lb.
1	308	507	527	876
2	79	129	136	222
3	37	59	63	101
4	22	34	38	59
5	15	23	25	39
6	11	17	19	28
7	9	13	15	22
8	7	11	12	18
9	6	9	11	15
10	6	8	9	13
11	6	7	8	11
12	5	6	7	10
13	5	6	7	9
14	5	5	7	8
15	4	5	6	8
16	4	4	6	7
17	4	4	5	7
18	4	4	5	6
19	4	4	5	6
20	4	4	5	6

Computed from the formula—No. of animals required $= \frac{t^2 \times 2s^2}{(\text{expected difference})^2}$

REVIEWS

MEAT, 1958: A review of production, trade, consumption and prices relating to beef, live cattle, mutton and lamb, live sheep, bacon and hams, pork, live pigs, canned meat, offals, poultry-meat; 112 pages, price *5s.* net. Obtainable from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1, or from H.M. Stationery Office.

The upward trend in world meat output was checked in 1957, but Commonwealth production increased further, nevertheless, international trade rose sharply and total exports were about 10 per cent greater than in 1938. Most of the increase in 1957 was in beef and veal, shipments of which reached a record level, but those of mutton and lamb were the lowest since 1951. Although continuing to be the dominant import market for carcass meat as a whole, the United Kingdom took only 66 per cent of world supplies in 1957 as against 84 per cent before the war. While Continental European demand remained heavy, an important feature of world trade in 1957 was the expansion in the United States imports of beef, particularly in those from New Zealand and Canada. This development became even more pronounced in 1958 when the decline in United States beef production caused world meat production as a whole to show some reduction.

BEEF AND VEAL

World production of beef and veal, now over 60 per cent greater than before the war, showed little change in 1957, but the Commonwealth total continued to increase following heavier output in Canada, the United Kingdom and New Zealand. Total exports rose by 16 per cent with Australia and Denmark recording the most marked increases; as in 1956 Commonwealth countries together accounted for about one-third of world trade. United Kingdom supplies of beef and veal were 2 per cent higher than in 1956 as both production and imports increased. Imports of chilled beef, which are drawn mainly from Argentina, rose by 5 per cent and a marked recovery in arrivals from Australia led to an increase of 7 per cent in receipts of frozen beef. *Per caput* consumption in the United Kingdom, at some 54 lb., was about ½ lb. higher than in 1956 and only ¾ lb. below the pre-war average. In Argentina, where consumption per head is the highest in the world, there was a decline of 2 lb. to 210 lb. in 1957 while Australian consumption fell by 8 lb. to 121 lb. in 1957-58; the most recent figures available for other important beef-eating countries are New Zealand 113 lb., United States 93 lb., and Canada 84 lb.

Despite the increase in supplies, prices of fresh and chilled beef in the United Kingdom during 1957 were, on average, slightly higher than in the previous year while a decline in production and imports caused an appreciable increase in all beef prices in the third quarter of 1958.

MUTTON AND LAMB

World production of mutton and lamb, of which Commonwealth countries account for about 60 per cent, showed little change in 1957, a substantial increase in Australian output being offset by reductions in New Zealand, the United States and Argentina. The downward trend in exports of mutton and lamb continued during the year but the total remained slightly greater than before the war. Although the recovery in shipments from Australia was more than outweighed by the decline in those from New Zealand, the Commonwealth's share of world trade rose to over 81 per cent. United Kingdom supplies of mutton and lamb declined slightly in 1957 as a small increase in domestic production was offset by a reduction in imports and *per caput* consumption fell by 1 lb. to about 22½ lb. Elsewhere, consumption rose by 3 lb. to 78 lb. per head in Australia but declined by 4 lb. to 76 lb. in New Zealand; while the *per caput* figure in Uruguay has been above 50 lb. in some recent years that in Argentina fell to 13 lb. in 1957.

PIG-MEAT

Owing mainly to a decline in the United States, world pig-meat production fell slightly in 1957 but was still about 38 per cent greater than in 1938. On the other hand, international trade in pig-meat was 4 per cent heavier than in 1956, but somewhat below the pre-war level. Compared with the previous year, the increase in 1957 was wholly due to heavier bacon exports, particularly those from the Irish Republic and Denmark, since trade in pork

declined slightly following a reduction in exports from Canada, the United States and Belgium. In the United Kingdom the upward trend in pork production was resumed in 1957 while both output and imports of bacon and ham were slightly above the previous year's level. As a result, pork consumption in the United Kingdom rose to over 17 lb. per head and that of bacon to nearly 25 lb.; for pork, this was almost 7 lb. more than before the war but for bacon there was still a decline of over 3 lb. Among other countries *per caput* supplies of pig-meat rose in 1957 by 8 lb. to 88 lb. in Denmark and by 4 lb. to 62 lb. in Western Germany but in Canada and the United States there were reductions of 4 lb. to 46 lb. and of 6 lb. to 61 lb. respectively.

Assistance to Producers

The various measures affecting production, marketing and prices in the main producing countries are described in an Appendix, which includes an analysis of the agricultural policies in the six Common Market countries as they affect meat. These countries, which aim to establish managed markets for farm products, have a substantial net import trade in meat and livestock. Other European countries supply nearly all their imports of pig-meat but Commonwealth countries have been important sources for beef in some years.

Dairy Produce, 1958: A review of production, trade consumption, and prices relating to butter, cheese, condensed milk, milk powder, casein, eggs, egg products and margarine; 130 pages, price *5s.* net. Obtainable from the Secretary, Commonwealth Economic Committee, 2, Queen Anne's Gate Buildings, Dartmouth Street, London, S.W.1, or from H.M. Stationery Office.

Milk production in many dairying countries continued to increase faster than liquid consumption in 1957 thereby releasing more milk for manufacture. Consequently, world output of dairy produce rose but the upward trend in international trade was checked as exports of all the chief products, with the exception of butter, were slightly lower than in 1956. Following the increase in exports from European countries, the Commonwealth's share of world trade in butter declined in 1957. On the other hand, the Commonwealth provided an increased proportion of the condensed milk and milk powder entering world trade. The importance of the United Kingdom as the principal import market increased even further in 1957.

Butter

Although butter production increased in 1957, the rise in exports, which brought the total to the highest post-war level, was partly due to the disposal of stocks built up in many European countries during the preceding year; nevertheless, world trade was still almost 20 per cent lower than before the war. Commonwealth supplies were sharply reduced last year and accounted for little more than two-fifths of world exports but the Commonwealth share of internaional trade has recovered in 1958 following a rise in shipments from New Zealand. The expansion of imports into the United Kingdom was reflected in a marked fall in prices and a rise in butter consumption to 17½ lb., the highest level since before the war. The gain for butter was at the expense of its direct substitute, margarine, and this movement has continued in 1958. In most other European countries, with the exception of Sweden, butter consumption also rose in 1957 but in the majority of countries this increase was accompanied by greater consumption of margarine. Estimates of butter and margarine consumption in a number of countries are given in the following table, the figures for Australia and New Zealand are for the twelve months ending 30th June of the year following that stated while those for margarine consumption in Western Germany are on a similar basis.

Estimated Consumption of Butter and Margarine
(*lb. per head*)

Country	Butter			Margarine		
	Pre-war	1956	1957	Pre-war	1956	1957
United Kingdom	24·1	15·6	17·5	10·0	16·9	15·1
Australia	32·6	28·0	28·3	4·9	8·3	8·4
New Zealand	42·8	43·4	43·0	4·3	—	—
Canada ..	31·9	20·5	20·3	—	7·7	7·8
Denmark	18·3	19·6	22·0	47·4	43·9	44·1
Netherlands	12·3	6·4	8·6	15·7	43·9	42·5
Western Germany	19·4	15·2	16·1	13·4	28·0	26·7
Norway ..	20·1	7·1	7·9	41·2	55·1	47·8
Sweden ..	24·1	19·2	17·4	20·5	33·3	35·3
United States ..	16·6	8·7	8·5	2·9	8·2	8·6

Cheese

While world butter production in 1957 remained lower than pre-war, that of cheese was 60 per cent above the 1938 level. As output in the United Kingdom was a record and production in New Zealand remained high, the Commonwealth share of world production was unchanged but the downward trend in the proportion of international trade of Commonwealth origin, which became apparent in 1953, continued. However, the decline in exports from the Netherlands resulted in New Zealand becoming once again the world's largest exporter.

Condensed Milk and Milk Powder

World production of condensed milk showed a slight reduction in 1957 mainly due to lower output of evaporated milk in the United States, but the expansion in milk powder production continued. The Commonwealth has shared fully in the growth in the milk powder output, a record level of production being reached in the United Kingdom and Canada during 1957. Thus, with the decline in overseas disposals of skimmed milk from the United States, the Commonwealth accounted for nearly one-third of world trade.

Assistance to the Dairy Industry

The Governments of nearly every country provide some form of assistance to milk producers, either in the form of deficiency payments or by other measures, such as control of imports and storage programmes, or by fixing support prices at which official agencies are prepared to buy dairy products offered to them. Measures of assistance of this kind are analysed in an Appendix which also includes an account of the relevant sections of the treaty establishing the European Common Market and of the measures currently used to assist the dairy industries in the six participating countries (France, Italy, Western Germany, Belgium, Luxembourg and the Netherlands). In 1957 the six countries as a unit had a net import balance of over 20,000 tons of butter and almost 9,000 tons for cheese. In the first half of 1958 the position changed radically for butter since the lower import requirements of Western Germany, Italy and Belgium led to a net export balance of 9,000 tons for the six.

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